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March,	,,	,,	,,	5.30	,,
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September,	,,	,,	,,	5.30	,,
October,	,,	,,	,,	5	,,
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A GUIDE

TO THE

FOSSIL REPTILES, AMPHIBIANS, AND FISHES

IN THE DEPARTMENT OF

GEOLOGY AND PALÆONTOLOGY

IN THE

BRITISH MUSEUM (NATURAL HISTORY),

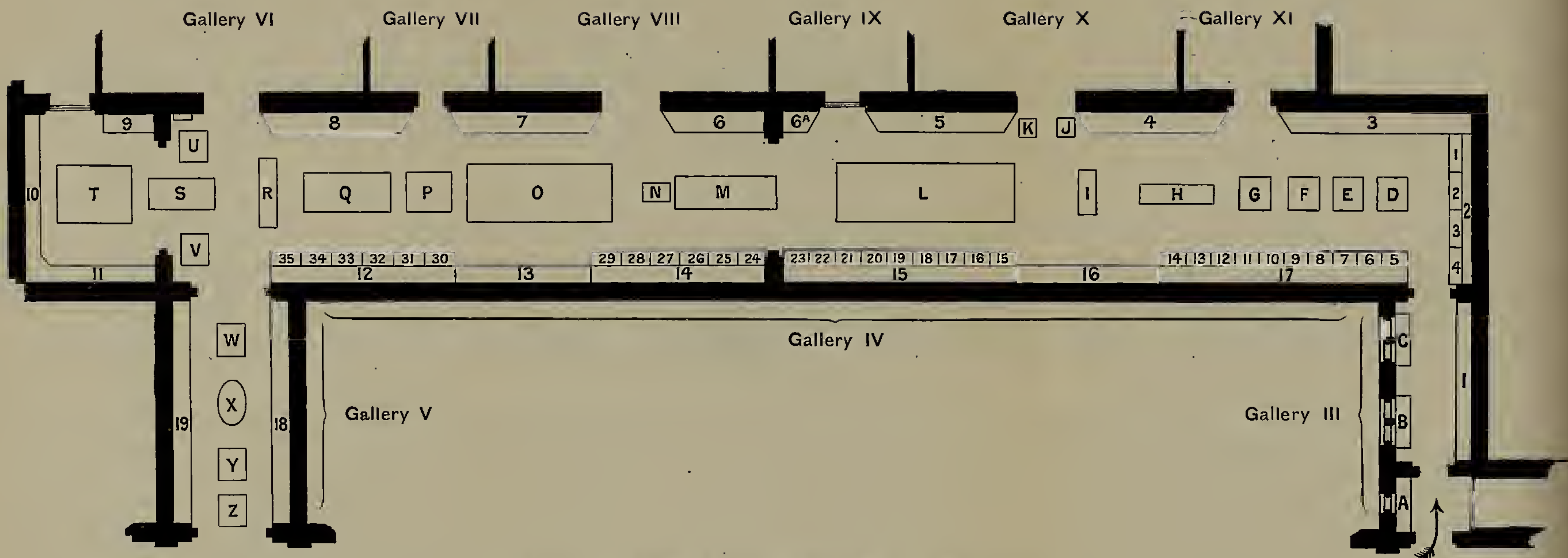
CROMWELL ROAD, LONDON, S.W.

WITH 8 PLATES AND 116 TEXT-FIGURES.

EIGHTH EDITION.

LONDON:
PRINTED BY ORDER OF THE TRUSTEES.
1905.

PRICE SIXPENCE.



PLAN OF THE GALLERIES OF FOSSIL REPTILES AND AMPHIBIANS (III, IV, V).

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[*Frontispiece.*

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PREFACE.

SINCE the last edition of the "Guide to Fossil Reptiles and Fishes" was published in 1896, the additions to the collection have been so numerous, and knowledge has advanced so much, that the book has now been entirely re-written by Dr. A. Smith Woodward, the Keeper of Geology. The present issue, however, retains all the original features of the Guide, and is not in any sense a systematic treatise. Its arrangement is determined by that of the cases and specimens, and it sometimes refers to trivial details which are of interest solely to visitors actually in the Galleries.

As fossils can only be understood by those who have some acquaintance with the existing world of life, this Guide assumes on the part of the reader at least as much elementary knowledge as is contained in the Guides to the Department of Zoology.

Many of the specimens bear small discs of green or red paper. Those marked with green discs are either "type-specimens" or have been described and illustrated in some scientific work, to which a reference is given on the label. Those marked with red discs have been merely noticed or briefly described in print.

E. RAY LANKESTER,
Director.

June, 1905.

INTRODUCTION.

OBJECTS much resembling fishes, shells, plants, and other remains of living things, have been noticed in rocks from time immemorial. They are so abundant and conspicuous in some of the countries round the Mediterranean, where the Greek and Roman civilisations flourished, that they cannot fail to have attracted the attention of the earliest observers. Herodotus, for example, referred to sea-shells from the stone quarries in the hills of Egypt and the Libyan desert. Other contemporary philosophers and writers made similar observations, and most of them appear to have reached the very natural conclusion that these petrified relics were originally buried in the bed of the sea, which had hardened and become dry land through the retreat of the waters.

At this early period in the study of natural philosophy, however, it was a common belief that animals could originate from the mud or slime of lakes and rivers. There was therefore another reasonable explanation of their occurrence as petrifactions in stone which seemed simpler, because it did not involve any startling theories as to great changes in the relations of land and sea. If certain animals could be generated in mud, it appeared quite probable that they should sometimes remain concealed in their native element without reaching the surface, and in that case they would become hardened into stone itself. As Theophrastus remarked concerning petrified fishes, they might have "either developed from fresh spawn left behind in the earth, or gone astray from rivers or the sea into cavities of the earth, where they had become petrified." These bodies thus appeared to be mere curiosities, and they were treated as such by Aristotle,

who was content to regard them as produced by some plastic force in the rock which he could not explain.

The authoritative opinion of Aristotle was almost universally accepted by the few writers who considered the subject before the revival of learning towards the beginning of the sixteenth century. By this time the numerous shells, teeth, and fish-remains met with in the stone quarries of Italy had induced several observers in that country to reconsider the question of their true nature. Similar discoveries in other European countries were also being discussed in their bearing on the same problem. The objects found in stone were now closely compared with the shells, teeth, and skeletons of the animals most nearly resembling them which still lived in the Mediterranean sea. The plant-remains were also studied deeply in connection with the leaves of the known existing vegetation. The result was that, although many observers still adhered to the long-prevalent belief, some of the most philosophical minds were compelled by strict reasoning to admit that the *fossilia* (Latin, "things dug up"), or fossils, as they were now commonly termed, were really the remains of the once-living animals and plants which they appeared to represent. Leonardo da Vinci, the well known painter, was one of the first to support this opinion with unanswerable arguments; while Steno, a Professor in the University of Padua, more than a century later, made it impossible any longer to doubt his demonstration of the facts. Steno's collection was acquired by the English Gresham Professor, John Woodward, who bequeathed it to the University of Cambridge, where it is still preserved in the Woodwardian Museum.

The true nature of fossils was thus settled by the beginning of the eighteenth century, and the next problem was to explain how the remains of sea-animals had been buried in the rocks far inland and at great heights among hills and mountains. For at least sixty years it was the prevailing opinion that all the phenomena could be accounted for by the Deluge recorded in the Pentateuch. There were, however, many difficulties in accepting this explanation, and the discussions at the time led to a most detailed study of the manner in which the fossils were grouped and distributed in the different kinds of rock. Observations accumulated at a remarkable rate, until, by the end of the eighteenth century, it became quite clear that the fossilised animals and plants could not have lived all together at one

time, but belonged to many different periods of the earth's history. Their destruction and burial, therefore, could not be ascribed to any single great catastrophe. It was demonstrated that during past ages the distribution of land and sea, mountains and plains, had frequently changed—that, in fact, rain, rivers, waves, currents, volcanoes, and phenomena like earthquakes, were continually altering the earth's surface, even under the eyes of man himself. The fossils were proved in most cases to be buried in displaced portions of sea-bottom, and in the mud of dried-up lakes; and it was realised that the relative ages of these deposits could be determined by the order in which they lay one upon another. Thus arose the true "science of the earth," which was named **Geology** by De Luc in 1778.

An English civil engineer, William Smith (1769–1839), was perhaps the first to realise fully the possibilities of this new branch of learning. His profession necessitated much travel through the country, and his interest in the distribution of fossils in the different kinds of rock led him to make a large collection, which was acquired by the British Museum in 1816, and is now exhibited in Gallery No. 11 of the Department of Geology. His published maps and writings prove that the various features of the landscape, in districts where fossils occur, are naturally carved out of layers of rock, which are simply old sea-beds or lake-beds piled one upon another, the oldest at the bottom, the newest at the top, each containing its own definite and invariable set of fossils. They also show that in most cases when these old sediments were raised into dry land, they were tilted in various ways from their originally horizontal position; so that it is often possible in a short walk to pass over the cut edges of many successive layers, perhaps hundreds of feet in thickness, representing immense periods of time.

While Smith and others were busily engaged in collecting fossils and observing their distribution, Blumenbach, Cuvier, Lamarck, Brongniart, and other naturalists were occupied with a detailed study of the fossils themselves. They soon demonstrated that, while most of these petrified remains could be interpreted by comparing them with the life of the present world, a large proportion represented animals and plants no longer existing. They also observed that the older the fossils, the more strikingly different they were from any animals and plants now living. It therefore

became evident that fossils afforded a means of discovering the past history of life on the earth—of determining the gradual stages by which our present animals and plants have become what they are, and have assumed their present geographical distribution. Thus was attained the "science of ancient life," which was named **Palæontology** by H. D. de Blainville and Fischer von Waldheim in 1834.

The Department of Geology in the British Museum chiefly deals with fossils from the latter point of view, and attempts to explain the main features in the life of the Present by reference to that of the Past.

Note to the Geological Time-scale.—The names in the three columns to the left are applied only to periods of time. The names in the two columns on the right are those of actual strata deposited during the time-periods opposite which they are placed. These strata or rock-groups are only a few out of the many that might have been mentioned, and it must not be inferred that those in the European column are the precise equivalents of those next them in the British column. It is just because rock-formations in different parts of the world so rarely are equivalent, that a time-scale is needed to which each can be referred. The absolute duration of the divisions on the time-scale is a matter of pure conjecture; but their relative duration can be roughly estimated from the thickness of the rocks. An attempt is made to represent this relative duration by the diagram to the right, which is based on the thickness of the rocks in N.W. Europe.

A GEOLOGICAL TIME-SCALE, WITH EXAMPLES OF FOSSILIFEROUS ROCKS.

Eras.	Epochs.	Ages.	British.	European.
CAINOZOIC or TERTIARY.	HOLOCENE	PRESENT DAY	Blown sand, alluvium, beaches, tufa, peat, shell-beds, &c., as now forming.	
		HISTORIC.		
		NEOLITHIC.		
	PLEISTOCENE	PALÆOLITHIC	Alluvium, &c., as above; valley-gravels, boulder-clays, brick-earth.	
		GLACIAL	Norfolk Forest-bed, Wexford Gravels.	
	PLIOCENE	SICILIAN.		
		ASTIAN	Norwich and Red Crags.	
		PLAISANCIAN	Coralline Crag; Lenham-beds	Pikermi-beds.
	MIOCENE	TORTONIAN.		
		HELVETIAN	.. ..	Oeningen molasse.
		BURDIGALIAN	.. ..	Globigerina Lst., Malta.
		AQUITANIAN	.. ..	Beauce Limestone.
	OLIGOCENE	RUPELIAN	Hamstead.	
		TONGRIAN	Bembridge	Sables d'Etampes.
		PRIABONIAN	Osborne and Headon	Phosphorites of Quercy.
	EOCENE	BARTONIAN	Barton and Bagshot	Gypsum of Montmartre.
		LUTETIAN	Bracklesham	Calcaire grossier.
		LONDINIAN	London Clay	Sables de Cuise.
		THANETIAN	Thanet Sands	Sables de Bracheux.
		MONTIAN	.. ..	Poudingue de Ciply.
MESOZOIC or SECONDARY.	CRETACEOUS — UPPER	DANIAN	Chalk in Norfolk and Charing detritus	Maestricht Chalk.
		SENONIAN	Upper Chalk	Gosau-beds.
		TURONIAN	Middle Chalk	Pläner-Mergel.
		CENOMANIAN	Lower Chalk; Chalk Marl.	Tourtia.
		ALBIAN	Upper Greensand; Red Chalk; Gault.	
	LOWER	APTIAN	Lower Greensand	Schratten-Kalk.
		URGONIAN	Speeton Clay; Tealby Beds } Wealden	Orbitolite Limestone.
		NEOCOMIAN	Spilsby; Purbeck } Wealden	Valangian, Berriasian.
	JURASSIC — OOLITIC	PORTLANDIAN	Portland Stone	Tithonic.
		KIMMERIDGIAN	Kimmeridge Clay	Lithographic Stone.
		CORALLIAN	Corallian Limestone; Ampthill Clay	Sequanian.
		OXFORDIAN	Oxford Clay	Branner Jura ζ.
		CALLOVIAN	Kellaways Rock	,, ,, ζ.
		BATHONIAN	Cornbrash; Forest Marble; Great Oolite	,, ,, ϵ.
		BAJOCIAN	Inferior Oolite, Yorkshire Estuarine	,, ,, γ, δ.
		AALENIAN	Northampton Sands	,, ,, α, β.
	LIASSIC	TOARCIAN	Bridport and Midford Sands, Upper Lias.	Schwarzer Jura ϵ, ζ.
		PLIENSBACHIAN	Marlstone, Middle Lias	,, ,, γ, δ.
		SINEMURIAN	Lower Lias	,, ,, α, β.
	TRIASSIC	RHAETIAN	White Lias; Tea-green Marls	Kössener Schichten.
		KEUPERIAN	Waterstones, Elgin Sandstone	Keuper and Raibl Beds.
		CONCHYLIAN	Pebble Beds, Variegated Sandstone	Muschelkalk, Bunter.
PALÆOZOIC or PRIMARY.	PERMIAN	PUNJABIAN	Red Marls & Sandstones, Magnesian Limestone; Penrith Beds.	Zechstein.
		ARTINSKIAN		Rothliegende. Bohemian gas-coal.
	CARBONIFEROUS.	OURALIAN	Coal Measures.	
		MOSCOVIAN	Millstone Grit; Yoredale Beds.	
		BERNICIAN.	Mountain Limestone; Culm.	
	DEVONIAN	CONDRUSIAN	Upper Devonian } Old Red Sandstone	Psammites du Condroz.
		EIFELIAN	Middle ,, } Old Red Sandstone	Calceola Limestone.
		COBLENTIAN	Lower ,, } Old Red Sandstone	Hunsrück Slates.
	SILURIAN	LUDLOVIAN	Downton and Ludlow Series	Gotland Limestone.
		WENLOCKIAN	Wenlock and Woolhope Series.	Cyrtograptus Shales.
		VALENTIAN	Tarannon and Llandovery Series	Pentamerus Limestone.
	ORDOVICIAN	CARADOCIAN	Bala, Chirbury and Caradoc Series	Grès de May.
		LLANDEILIAN.	Llandeilo and Middleton Series.	
		ARENIGIAN	Arenig, Shelve, and Skiddaw	Orthoceras Limestone.
			Tremadoc and Shineton Beds	Ceratopyge Limestone.
	CAMBRIAN	OLENIDIAN.	Lingula Flags	Olenus Shales.
		PARADOXIDIAN	Menevian Series	Andrarum Limestone.
		OLENELLIAN	Harlech, Caerfai, and Hartshill Series	Eophyton Sandstone.
	PRECAMBRIAN	. . . .	A large series of rocks of which only the uppermost have yielded fossils, and those for the most part obscure, as the worm-burrows in the Longmynd.	

RANGE IN TIME OF LIFE-GROUPS.

Plants — Invertebrates — Fishes — Amphibians and Reptiles — Birds — Mammals — Man

[The name of each group is printed opposite the Epoch during which it was the dominant type.]

RELATIVE LENGTHS OF EPOCHS.

TERTIARY.	1,600 ft.
CRETACEOUS.	2,500 ft.
JURASSIC.	5000 ft.
TRIASSIC.	3000 ft.
PERMIAN.	1,500 ft.
CARBONIFEROUS.	12,000 ft.
DEVONIAN.	4000 ft.
SILURIAN.	7000 ft.
ORDOVICIAN.	15,000 ft.
CAMBRIAN.	12,000 ft.
PRECAMBRIAN.	Extent unknown.

A GUIDE

TO THE

FOSSIL REPTILES, AMPHIBIANS,

AND

FISHES.

GALLERIES Nos. 3, 4, 5, 11.—FOSSIL REPTILES.

Reptiles, or "creeping things," are appropriately named when the existing world alone is considered. It is true that most lizards run with great rapidity on land, while a few (such as *Draco*) glide through the air from branch to branch among trees. It is also true that some crocodiles are both good runners and expert swimmers. All these animals, however, progress with a distinctly gliding or sinuous creeping motion, and so soon as they stop the whole weight of their body rests directly on the ground. Their limb-bones are tipped with a cap of cartilage or gristle, and are not united by well-fitting joints like those of mammals or birds. Consequently, the limbs are used merely for progression or balancing, and do not serve either for habitual support of the body or for many of the other purposes to which they are adapted among the higher warm-blooded animals just mentioned.

The predecessors of these "creeping things," presumably including their ancestors, are revealed by fossils, and prove to be remarkably different from those which now survive. During the Secondary or Mesozoic Period of the earth's geological history reptiles occupied the place in the economy of Nature which has since been usurped by mammals and birds. There were land-reptiles, both great and small, with supporting

limbs as effective as those of an elephant or of an ostrich. Some of these were massive vegetable-feeders as ponderous as ground-sloths; others were slim carnivores as agile as cats; while a few were clearly adapted for hopping or jumping. There were also sea-reptiles with paddles formed solely for swimming, and some of these animals had the outward shape of dolphins or porpoises, while others were of unique proportions, and a few might have passed for the traditional sea-serpent. Moreover, there were numerous true flying reptiles with well-developed wings supported by bones of a texture and construction now peculiar to birds.

The Secondary period was, therefore, the "Age of Reptiles," just as the Tertiary period is the "Age of Mammals and Birds." Indeed, the casual observer on entering the Gallery of Fossil Reptiles may be pardoned for asking the reason why many of them are actually placed in the cold-blooded Reptilian Class and not among the warm-blooded mammals or birds. The brief explanation is, that they show a combination of peculiarities in the skeleton which is exclusively characteristic of reptiles in the existing world. Although some of the huge Dinosaurs bear an outward resemblance to mammals, they cannot be associated with those quadrupeds, because their lower jaw consists of several pieces and is hinged to the skull by a large separate bone (the "quadrate"), while their ankle-joint is not at the root of the toes but between the two rows of ankle-bones. The Ichthyosaurs are not fishes, because their nose-passages and their chest-bones show that they breathed by lungs; while they are not porpoise-like mammals, because their lower jaw consists of several pieces and their cheek is covered with separate bones which encircle the peculiar "quadrate" bone. The Pterodactyls are not birds, because well-preserved fossils prove that they had no feathers, while their wings were arranged on a different pattern; and they are not flying mammals, or bats, because they exhibit the complexity of the lower jaw and its connections already mentioned as characteristic of walking and swimming reptiles.

In short, the modern snakes, lizards, crocodiles, turtles and tortoises are merely the degenerate survivors of a race which no longer occupies foremost rank. They give very little idea of the Class Reptilia as it was at its most flourishing period.

Class III.—REPTILIA.

Order I.—SQUAMATA.

Sub-order 1.—Ophidia.

Table-case E.

The snakes appear to be essentially if not exclusively Tertiary reptiles, and their fossil remains are both rare and fragmentary. Fine portions of the vertebral column of sea-snakes (*Palæophis*) from the Lower Eocene (London Clay) of Sheppey are exhibited; and there are also some detached vertebræ of another large sea-snake (*Pterosphenus*), which is found with *Zeuglodon* in the Eocene both of Alabama, U.S.A., and of the Fayum, Egypt. The largest known snake is an extinct kind of python, *Gigantophis garstini*, from the Middle Eocene of the Fayum, represented by vertebræ and a portion of jaw, which seem to show that the animal attained a length of not less than 50 or 60 feet.

Sub-order 2.—Lacertilia.

Table-case F.

Ordinary lizards are not definitely known before the Tertiary period, but a few detached jaws (*Macellodus*) from the Purbeck Beds, and teeth (*Coniasaurus*) from the Chalk, may perhaps belong to reptiles of this kind. Like those of the snakes, all their fossil remains are very fragmentary, and a typical collection is exhibited in Table-case F. Some of the early Tertiary lizards are interesting on account of their distribution. *Iguana*, for example, which is now characteristic of tropical America, is represented by fossils in the Upper Eocene of Hampshire and in the Oligocene Phosphorites of France. Among Pleistocene species, *Varanus priscus*, from the river deposits of Queensland, is noteworthy as being the largest known lizard, its length being probably not less than 6 feet.

Sub-order 3.—Dolichosauria.

Table-case F.

During the Cretaceous period there were numerous swimming sea-reptiles, which seem to have been neither snakes nor lizards, but intermediate between these modern groups. They were of two kinds—one with a small head,

Table-case F.

rather slender neck, and lizard-like limbs—the other with a large head, short and stout neck, and well-formed paddles. The first kind is represented by small reptiles, which are named Dolichosauria ("long lizards") in allusion to their elongated shape. The backbone is indeed snake-like, and the vertebræ when found isolated have sometimes been mistaken for those of snakes. *Dolichosaurus* itself is represented in Table-case F by a fine specimen from the Chalk of Burham, Kent. There is also a nearly complete skeleton of a closely related animal, in hard limestone of the same geological age, from Lesina, Dalmatia.

Sub-order 4.—**Mosasauria.**

Wall-case 1.

The second group of Cretaceous swimming reptiles just mentioned comprises large animals, shaped more or less like elongated porpoises or ichthyosaurs. Their skull resembles that of a lizard, but the jaws are as loose as those of snakes

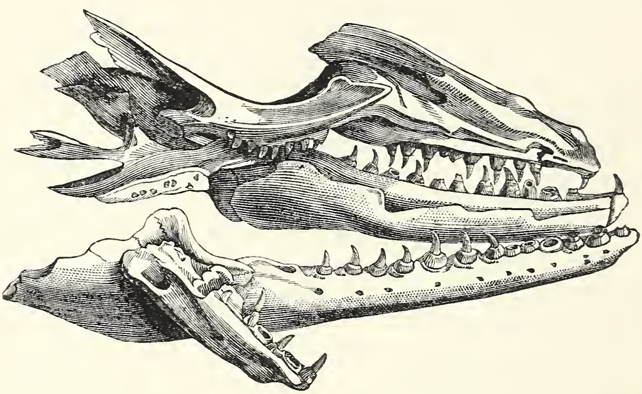

Fig. 1.—Jaws of *Mosasaurus camperi*, from the Upper Chalk of Maastricht, Holland; about one-fifteenth nat. size. (Wall-case 1.)

for swallowing bulky prey, while some of the palate-bones bear recurved teeth. The teeth themselves are large and conical, and firmly fixed by swollen bases to the supporting jaws (Fig. 1). The eye is surrounded by a ring of "sclerotic plates." The vertebræ are united by shallow ball-and-socket joints, the ball being posterior. Both pairs of limbs and their supports are fundamentally like those of a lizard, but modified into effective paddles (Fig. 2). The toes are flattened from

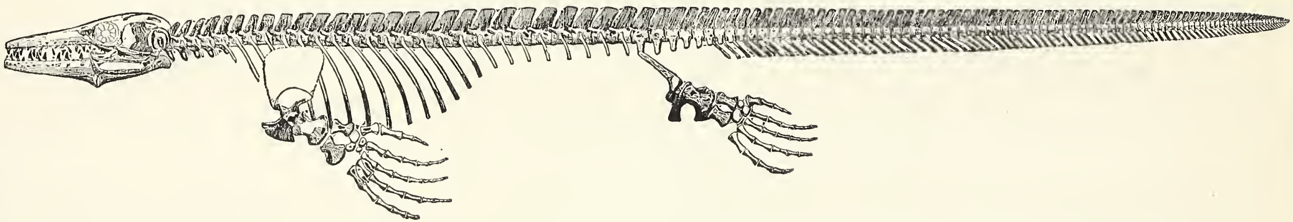

Fig. 2.—Skeleton of a Mosasaurian (*Platecarpus coryphæus*), from the Upper Cretaceous of Kansas, U.S.A.; about one twenty-fifth nat. size. (After S. W. Williston.)

Wall-case 1.

side to side, lengthened by a multiplication of the joints, and destitute of claws. There is no armour, except perhaps a partial covering of thin scales. The typical genus is *Mosasaurus* ("Meuse-lizard") itself, so named because it was first found in the Chalk of Maastricht in the valley of the Meuse. This is represented in Wall-case 1, not only by a plaster cast of the skull and jaws of *M. camperi*, now in the Paris Museum (Fig. 1), originally described by Cuvier, but also by numerous other remains of the same species from Maastricht, including a fine piece of jaw presented more than a century ago by Dr. Peter Camper, the celebrated Dutch anatomist. *Mosasaurus camperi* must have been a very large animal, probably not less than 50 feet in length. Teeth and other fragments of *Mosasaurus* and allied genera (*Liodon*, etc.) are also exhibited from the English Chalk. Instructive portions of the skeleton of a smaller Mosasaurian, *Platecarpus* (Fig. 2), are shown in slabs of Chalk from Kansas, U.S.A. A hind paddle of *Tylosaurus*, from the same formation and locality, illustrates the nature of the Mosasaurian limb. There is also from the Kansas Chalk a skull of *Clidastes*, a relatively small animal shaped remarkably like a snake, but with the usual paddles, and with a deepening of the spines of the hindmost tail-vertebræ, which suggests that it was originally provided with a vertical tail-fin. Fragments of jaws of a large *Liodon* from the Greensand of New Zealand indicate the wide range of the Mosasaurians in the Cretaceous sea.

Order II.—**ORNITHOSAURIA.**

Wall-case 2. Table-cases 1–4. D.

True flying reptiles lived throughout the Secondary period, and are known by many nearly complete skeletons from the Lias of England and Germany, the Lithographic Stone (Kimmeridgian) of Germany, and the Chalk of Kansas, U.S.A. They form the Order Ornithosauria ("bird-lizards"), or Pterosauria ("wing-lizards"), and are commonly referred to as Pterodactyls, because Cuvier gave the name of *Pterodactylus* ("wing-finger") to the first specimens when he originally described them and recognised their true nature. In these reptiles the skeleton is very light, and composed of hard, dense bone like that of birds of flight; while the vertebræ and limb-bones have well-fitting joints, and are hollowed to receive air from the lungs. The head is shaped like that of a bird, and similarly fixed at right angles to the neck. The brain is comparatively small, but in the arrange-

ment of its parts it bears a most striking resemblance to the brain of a bird. The neck is stout and mobile, its large vertebræ being united by ball-and-socket joints, in which the ball is posterior. The body is relatively small, and the tail varies in extent, being sometimes long and slender, sometimes very short. The wings are disproportionately large, and the wing-membrane is supported by the much-elongated fifth finger, while the other fingers remain small or even rudimentary. The breast-bone is expanded as in birds, and keeled in front to accommodate the muscles for flapping the wings. The hind limbs are weak, and four of the slender toes bear claws. No armour of any kind has been noticed even in the finest known specimens from the Lithographic Stone of Bavaria, which exhibit clear impressions of the smooth wing membrane.

Wall-case 2. Table-cases 1–4. D.

The latest Pterodactyls are the largest, and are best

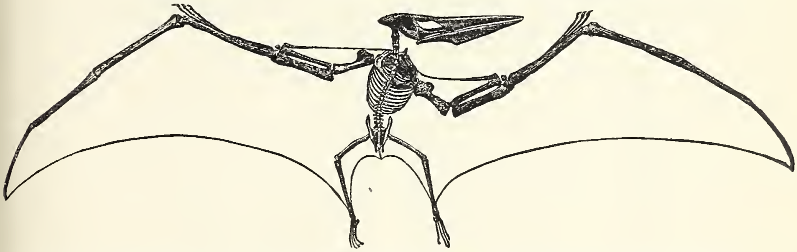

Fig. 3.—Skeleton of a toothless Flying Reptile (*Pteranodon occidentalis*), from the Upper Cretaceous of Kansas, U.S.A.; about one fifty-fourth nat. size. (Wall-case 2.)

known by skeletons from the Chalk of Kansas. They are well illustrated by a fine pair of wings of *Pteranodon*, which are mounted on a picture of the complete skeleton in Wall-case 2 (Fig. 3). The outlines and proportions of the bones painted in this picture are based partly on specimens in American museums, partly on imperfect remains in Table-cases 3, 4. The jaws form a sharp, toothless beak, and the head rises behind into a prominent crest. The breast-bone is short and broad, with the keel in front; and the shoulder-blade on each side is firmly fixed to the backbone to strengthen the socket in which the wing works. The wing-fingers, of which the actual bones are shown, are immense, and the supposed extent of the membrane they originally supported is indicated by colour. The total expanse of the wings is about eighteen feet, and it is thought that the

Wall-case 2. Table-cases 1–4. D.

principal muscles which raised them upwards had their origin in the crest at the back of the head. Three diminutive fingers with conspicuous claws occur as mere splints grafted on the basal piece of each wing-finger. The hind legs are shown to be quite weak, and could scarcely have sup-

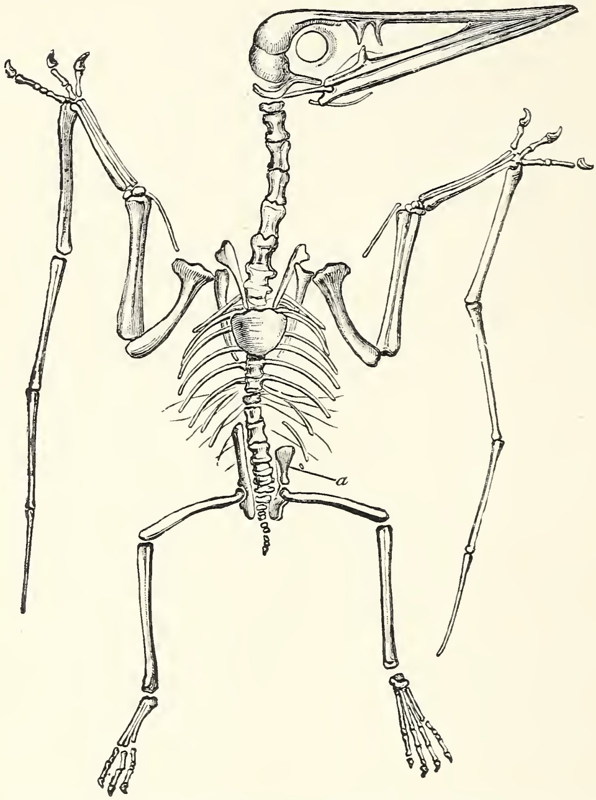

Fig. 4.—Skeleton of a short-tailed Flying Reptile (*Pterodactylus spectabilis*), from the Upper Jurassic (Lithographic Stone) of Eichstätt, Bavaria; nat. size. *a*. pubic bone. (Table-case 1.)

ported the whole weight of the animal when at rest or moving on the ground. The remains of *Pteranodon* in Table-case 4 exhibit the hind legs in association with the wings and the nearly complete breast-bone. All the specimens from the Kansas Chalk are flattened in the rock and broken by pressure; but a few bones of similar gigantic Pterodactyls from

the English Chalk have their central cavity filled with rock, and so preserve their original shape. An incomplete humerus from the Chalk of Burham, Kent, in Table-case 3 is especially noteworthy in this respect: where sharply cut across in three places it displays the extreme thinness of the dense bony wall, and also exhibits traces of an internal framework of delicate struts to strengthen the expanded upper end. Most of the English Cretaceous Pterodactyls (*Ornithocheirus*) were provided with large teeth in sockets, as shown by portions of jaws from both the Chalk and the Cambridge Greensand. Some of their American contemporaries were also toothed.

Wall-case 2. Table-cases 1-4. D.

The Jurassic Pterodactyls are much smaller than those which followed them in the Cretaceous period. Some of the

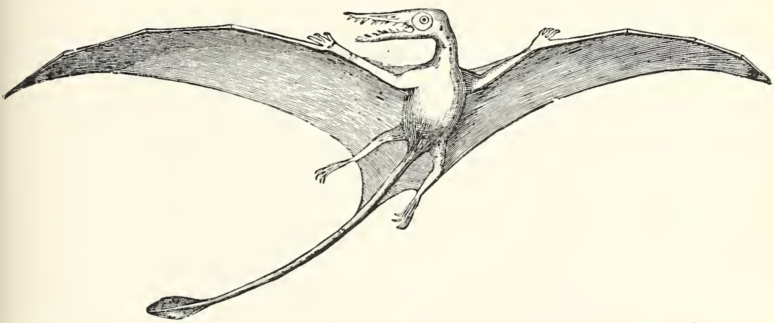

Fig. 5.—Restoration of a long-tailed Flying Reptile (*Rhamphorhynchus phyllurus*), from the Upper Jurassic (Lithographic Stone) of Eichstätt, Bavaria; one-seventh nat. size. (After O. C. Marsh.)

short-tailed forms (*Pterodactylus*, Fig. 4), exhibited in Table-case 1, are, indeed, no larger than sparrows or thrushes. All are provided with teeth in sockets, and all have three complete fingers with claws adjoining the base of the wing-finger. Their first finger, or thumb, is commonly supposed to be reduced to the little spur of bone which turns inwards to support the piece of membrane originally extending from the shoulder to the wrist. A long-tailed form (*Rhamphorhynchus*), with the slender-toothed jaws ending in front in a pointed toothless beak, is represented at the bottom of Wall-case 2 by several portions of skeletons from the Lithographic Stone of Bavaria. The grain of this stone is so fine that some specimens of *Rhamphorhynchus* have been found displaying impressions of the smooth wing-membrane. A

Wall-case 2. Table-cases 1–4. D.

plaster cast of the best of these fossils, now in the Yale University Museum, is exhibited, and justifies the late Professor Marsh's restoration of the animal reproduced in Fig. 5. It will be noted that there is a rudder-like expansion of the skin at the end of the long tail. Another long-tailed Pterodactyl (*Dimorphodon*) is also represented by some well-preserved portions of skeletons in slabs of Lias from Lyme Regis, Dorsetshire. Its head is disproportionately large and of remarkably light structure, with large teeth in sockets in front, small teeth behind. Its hind limbs are also relatively large and stout; and its long tail is strengthened by bony tendons. A plaster cast of the skull of another Pterodactyl (*Scaphognathus purdoni*), from the Upper Lias of Whitby, is noteworthy as displaying the shape and proportions of the brain (Table-case 1).

Order III.—**CROCODILIA.**

Wall-cases 1–3. Table-cases 5–12.

At the present day crocodiles live only in tropical and sub-tropical regions; but in the early part of the Tertiary period they had a much wider distribution, perhaps in consequence of the greater extent of genial conditions at that time. There cannot be much doubt, for example, that during the Eocene period the climate in the latitude of southern England was sub-tropical. True crocodiles lived in the rivers at the mouth of which the London Clay was deposited; and skulls of *Crocodilus spenceri* are exhibited from this formation near Sheerness in the Isle of Sheppey (Table-case 6, Wall-case 2A). Alligators (*Diplocynodon*), closely related to those now existing in tropical America, are also represented by fine skulls and numerous other remains from the Upper Eocene sands of Hordwell Cliff, Hampshire; while the same animals are proved by numerous fragmentary specimens to have survived in France and southern Germany until the beginning of the Miocene period. Even the long-snouted gavial (*Gavialis*), at present confined to the Indian region, seems to be represented by a portion of a jaw from the Middle Eocene of Bracklesham Bay, Sussex (Table-case 5); and one large skull from the Miocene of Austria, of which a plaster cast is exhibited in Wall-case 3, is essentially identical with the skull of *Tomistoma*, which now survives only in the Malay Peninsula and Archipelago. In warm countries where crocodiles still live, they were much more numerous and varied in former times than at the present day. There

are, for example, several skulls and jaws of extinct kinds from the Eocene of Egypt; while a large collection from the Pliocene Siwalik formation of India includes, among other interesting specimens, the snout of a colossal extinct gavial, *Rhamphosuchus crassidens*, which must have attained a length of about 50 feet (Wall-case 1). **Wall-cases 1–3. Table-cases 5–12.**

The typical modern crocodiles (Eusuchia or "perfect crocodiles") are peculiar in having their throat so constructed **Wall-cases 2a, 3. Table-cases 5–7.**

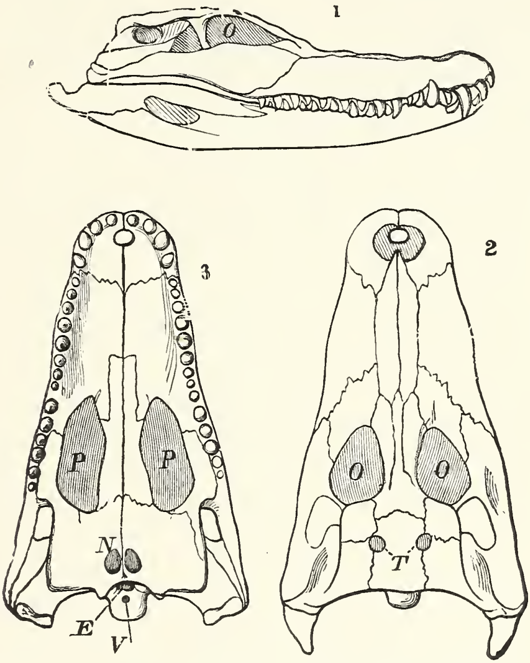

FIG. 6.—Skull of *Crocodilus palustris*, a species living in Western India and found fossil in the Pleistocene of the Narbada Valley. 1. Right side view. 2. Upper view. 3. Palate. All much reduced in size. *E*, opening of median eustachian canal; *N*, posterior nares; *O*, orbits; *P*, palato-pterygoid vacuities; *T*, supratemporal fossæ; *V*, basioccipital bone.

that they can keep their mouth open under water while drowning prey: they are also characterised by vertebræ united by ball-and-socket joints. A few Upper Cretaceous crocodiles agree with them in these features, a skull of *Thoracosaurus* from the Greensand of New Jersey (plaster cast in Wall-case 3) showing the characteristic palate, while vertebræ from the Chalk of France and the Cambridge

Wall-cases 2a, 3. Table-cases 5–7.

Greensand are of the typical concavo-convex pattern. All the Lower Cretaceous and Jurassic crocodiles, however, differ from those of more modern times in having the curious bony roof of the palate extending less far backwards, so that unless a soft piece of palate in their case was adapted to serve the same purpose as a plate of bone in the living crocodiles, they could not have kept their mouth open under water (compare Figs. 6 and 9). Their vertebræ were also more or less concave at both ends, not united by ball-and-socket joints; and their whole skeleton in most cases suggests a more exclusively aquatic mode of life than that of the existing crocodiles. In fact, the only Mesosuchia ("intermediate crocodiles")—as these reptiles are technically termed—which have

Wall-case 3. Table-case 8.

the outward appearance of modern crocodiles and alligators, are a few obvious marsh-dwellers from the Wealden and Purbeck formations. *Goniopholis*, with its broad head and powerful teeth, may well have preyed on land-animals which came to drink the water it haunted; while the dwarf

Table-cases 9, 10.

Theriosuchus and *Nannosuchus* are associated in the Purbeck Beds with numerous small land-mammals which would form most suitable food. All these marsh-dwellers were well armoured above and below with the usual thick, pitted, bony scutes, of which those on the back were firmly united by peg-and-socket joints as in the scales of ganoid fishes. Many of these scutes are exhibited in the collection, and they are well displayed on the slab of Purbeck stone containing *Goniopholis* (Wall-case 3), which was originally in Dr. Mantell's collection and excited much interest in 1839 when he described it under the name of "the Swanage Crocodile."

Wall-case 3. Table-case 11.

The extreme adaptation of a crocodile for life in the sea is shown by *Geosaurus* and *Metriorhynchus* (Fig. 7) from European Upper Jurassic rocks. These reptiles have the usual elongated snout of an aquatic animal, with rather large, laterally compressed teeth in sockets; but the external bones of the head are not much sculptured, some, indeed, being quite smooth. Their backbone turns sharply downwards at the end of the tail, and must originally have borne a vertical triangular tail-fin, like that of *Ichthyosaurus*. Their fore limbs are very small and in the form of paddles or flippers, while their hind limbs are crocodilian in shape, but relatively large for hard swimming. Bony plates are absent, so that the skin must have been as smooth as that of an Ichthyosaur, or porpoise. The original skull and other bones of *Geosaurus*

from the Lithographic Stone of Monheim, Bavaria, described by Sömmerring in 1816 as the remains of a gigantic lizard (*Lacerta gigantea*), are exhibited in Wall-case 3. Fine examples of *Metriorhynchus*, obtained from the Oxford Clay

Wall-case 3.
Table-case 11.

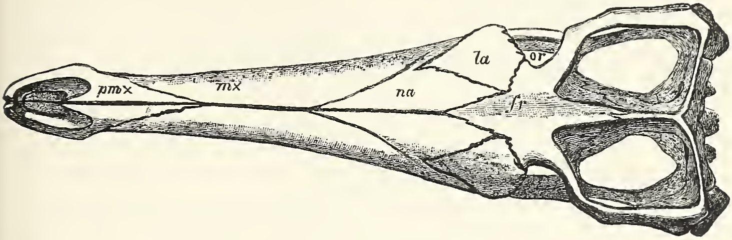

Fig. 7.—Upper view of skull of a marine Crocodile (*Metriorhynchus hastifer*), from the Kimmeridge Clay of Normandy; one-sixth nat. size. *fr.* frontal; *la.* lachrymal; *mx.* maxilla; *na.* nasal; *or.* orbit; *pmx.* premaxilla. (Allied species in Wall-case 3.)

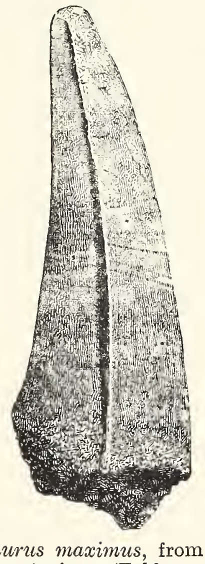

Fig. 8.—Tooth of *Dakosaurus maximus*, from the Kimmeridge Clay of Ely; nat. size. (Table-case 11.)

of Peterborough by Mr. Alfred Leeds, are also shown in the same case.

Some contemporary crocodiles, such as the slender *Steneosaurus* and the heavy *Dakosaurus* (Fig. 8), are well armoured

Wall-case 3. Table-cases 11, 12.

both above and below, but must also have been essentially marine animals. The Lower Jurassic crocodiles (*Teleosaurus*, *Pelagosaurus*, and *Mystriosaurus*) are similarly armoured. The scutes of the back are in one paired series, while those of the belly are smaller and polygonal, forming a plate of mosaic. *Teleosaurus* has very slender jaws with sprawling interlocking teeth, and is represented by several instructive fragments from the Great Oolite of Normandy and the

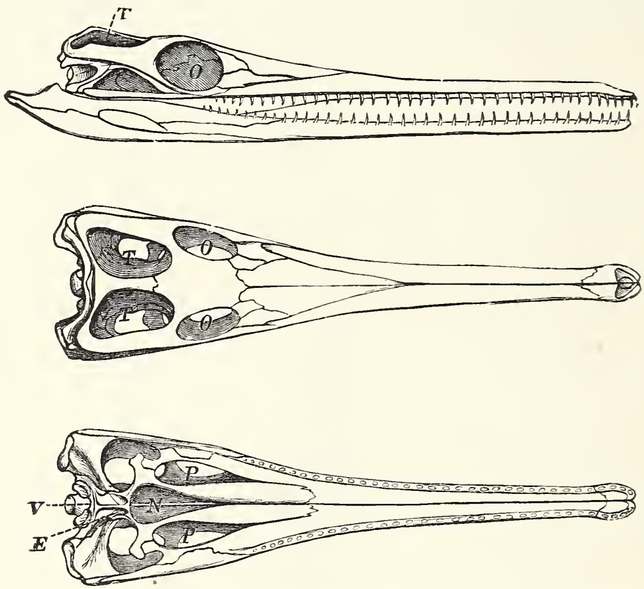

FIG. 9.—Skull of *Pelagosaurus typus*, from the Upper Lias of Normandy; one-quarter nat. size. Right side-view, upper view, and palate. *E.* opening of median eustachian canal; *N.* posterior nares; *O.* orbits; *P.* palatine vacuities; *T.* supratemporal fossæ; *V.* basioccipital bone. (After Owen. Table-case 12.)

Stonesfield Slate of England (Wall-case 3, Table-case 11). *Pelagosaurus* (Fig. 9), with equally slender jaws, is known by good skeletons from the Upper Lias of England, France, and Germany. Fragmentary remains of a small species, *P. typus*, from Normandy, in Table-case 12, are specially valuable as illustrating the chief features of its bones; and a model of a complete skeleton of the same species, exhibited in the Department of Zoology, Gallery of Reptiles, illustrates the general form and proportions of the reptile. The

incomplete skeleton of *Mystriosaurus* from Whitby, in Wall-case 3, is interesting from the fact that it is the actual specimen described as an "Alligator" by Chapman and Wooller in the Royal Society's Philosophical Transactions for 1758. Though most abundant in the Jurassic rocks of Europe, similar crocodiles seem to have been widely distributed in Jurassic seas. A head of *Steneosaurus* exhibited in Wall-case 3 was obtained from a Jurassic formation in Madagascar. **Wall-case 3. Table-cases 11, 12.**

Belodon (Fig. 10) and allied reptiles of the Triassic period have often been regarded as the primitive ancestors of the Crocodilia. The head of *Belodon*, as shown by fine specimens **Wall-case 3. Table-case 13.**

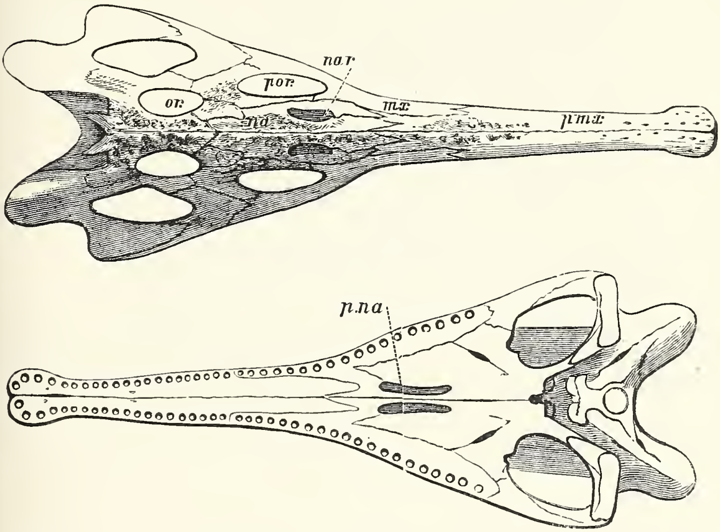

FIG. 10.—Skull of *Belodon kapffi*, upper and palatal views, from the Keuper of Würtemberg; about one-eighth nat. size. *mx.* maxilla; *na.* nasal; *nar.* external narial opening; *or.* orbit; *p.na.* posterior nares; *p.or.* pre-orbital vacuity; *pmx.* premaxilla. (After H. von Meyer. Wall-case 3.)

from the Upper Keuper of Würtemberg in Wall-case 3, certainly bears much resemblance to that of a long-snouted crocodile; while the back is armoured with scutes which are quite crocodilian (see also Table-case 13). The bones supporting the limbs, however, are very different from those of crocodiles, and suggest a close relationship with the contemporary Dinosauria and Rhynchocephalia. *Belodon* occurs

Wall-case 3. Table-case 13.

not only in Germany, but also in North America, while *Stagonolepis* is found in the Elgin Sandstones, Scotland (Wall-case 3).

ORDER IV.—**DINOSAURIA.**

Wall-cases 4–8. Table-cases 15–19. Cases I–O.

The land reptiles of the Jurassic and Cretaceous periods, with a few of their predecessors in the Trias, are usually grouped together under the name of Dinosauria ("terrible lizards"). They are most closely related to the crocodiles, but all possess well-formed limb-bones adapted for habitual support of the body on land, and some must have walked on all fours, while others can only have used their hind legs for progression. Their comparatively large tail suggests that they were ordinarily amphibious in habit and were good swimmers. Some are massive animals, and shown by their teeth to have been vegetable-feeders; while others have slender hollow bones and sabre-shaped cutting teeth, proving that they were active and fed on flesh.

SUB-ORDER 1.—**Sauropoda.**

Wall-case 4. Table-case 15. Cases I–L.

The large and stout unarmoured herbivorous Dinosaurs, which walked on all fours, have small five-toed feet and are named Sauropoda ("lizard-footed"). As shown by discoveries of nearly complete skeletons in the Jurassic rocks of North America (Fig. 12), their head is quite small, at the end of a very long and tapering neck, while their body is short and high and ends in a remarkably elongated tail. They are the largest known four-footed animals, some of them attaining a length of 80 or 90 feet. Notwithstanding the light construction of many of their vertebræ, they must have been too heavy for much activity on land, and it seems most probable that they haunted the sea-shore, where they lived habitually in the shallow water, browsing on sea-weeds like the existing sea-cows (Sirenia). The blunt and feeble teeth would suffice for such feeding, while the long neck would enable the reptile to reach the surface of the water for breathing even when walking on the bottom at a considerable depth. A plaster cast of a partially restored skeleton of *Diplodocus carnegii*, from the Jurassic of Wyoming, U.S.A., presented by Andrew Carnegie, Esq., is mounted in the Reptile Gallery of the Zoological Department, and exhibits all the characteristic

Photograph (by Mr. J. T. Pigs) of a reproduction in plaster of a Dinosaurian Land-Reptile (*Diplodocus carnegii*), 80 feet in length, from the Upper Jurassic, Wyoming, U.S.A. (Gallery of Reptiles, Department of Zoology.)

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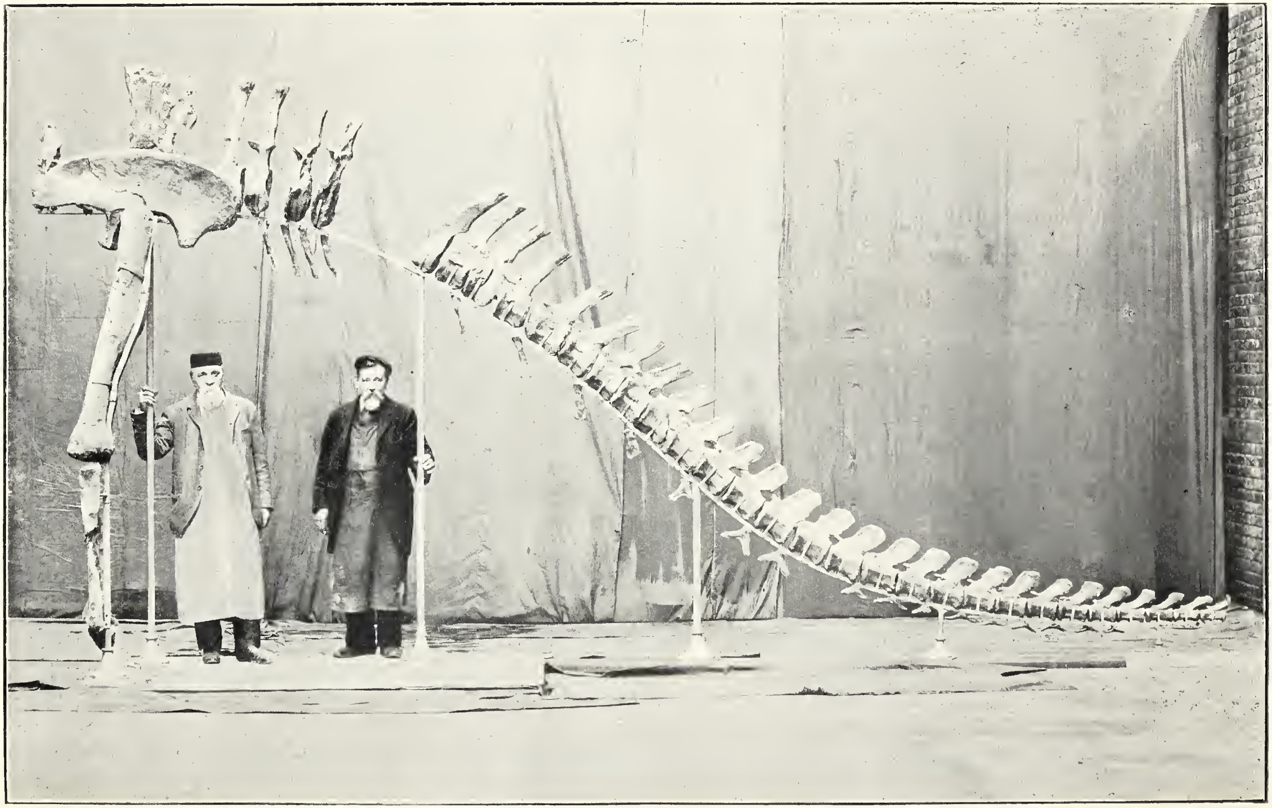


Hind Limb and Tail of a Dinosaurian Land-Reptile (*Cetiosaurus leedsi*), discovered by Mr. Alfred N. Leeds in the Oxford Clay near Peterborough; about one-fortieth nat. size. (Case L.)

features of the Sauropoda (Plate II). In end view the laterally compressed shape of the body is noteworthy, a strange contrast to the relative bulkiness of the largest warm-blooded quadrupeds or mammals. The nostrils open on the top of the head (Fig. 11), exactly as should be the case in an air-breather spending most of its time under water. The three inner toes bear large claws, and the two outer toes are diminutive. *Diplodocus* ("double beam") is so named because each posterior chevron bone (i.e. bone to cover and protect the blood-vessels on the lower face of the tail) consists of two separate bars slung in the middle—an arrangement unknown

Wall-case 4. Table-case 15. Cases I–L.

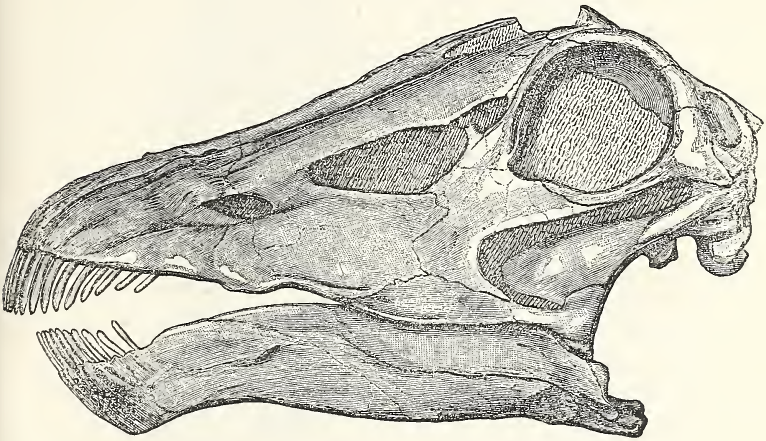


FIG. 11.—Skull and mandible of a Sauropodous Dinosaur (*Diplodocus*), left side-view, from the Upper Jurassic of Colorado, U.S.A.; one-sixth nat. size. The cleft at the summit of the head is the nostril, and the large round vacuity is the orbit. The diminutive brain-case is behind and partly between the orbits. (After O. C. Marsh.)

in any other animal when this Dinosaur was first discovered. In the Gallery of Fossil Reptiles many portions of closely similar Sauropoda are exhibited from English Jurassic and Wealden rocks. The finest specimen is the greater part of a tail, with the left hind limb and associated right fore limb of *Cetiosaurus leedsi*, discovered by Mr. Alfred N. Leeds in the Oxford Clay near Peterborough (Plate III.; Case L). The skeleton measures 10 feet 6 inches in height at the hip-region, and its total length when complete must have been nearly 60 feet. Detached bones of the same species from Peterborough, including a piece of the whip-like end of the tail,

Case L.

Wall-case 4. Table-case 15. Case L. are also shown; and there are placed for comparison (on black bases in the same Case) a few bones of larger species of the North American Sauropoda, *Diplodocus* and *Brontosaurus.*

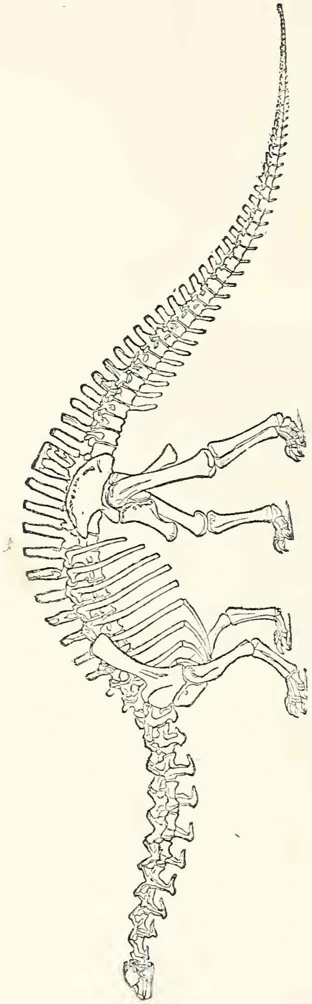
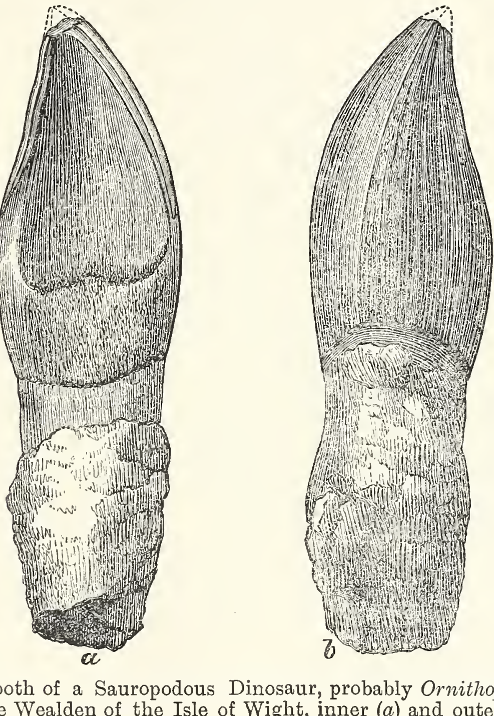


Fig. 12.—Skeleton of a Sauropodous Dinosaur (*Brontosaurus excelsus*), from the Upper Jurassic of Wyoming, U.S.A.; about $\frac{1}{150}$ nat. size. (After O. C. Marsh.)

Stand I. The femur, tibia and fibula of *Brontosaurus* (Fig. 12) from the Upper Jurassic of Wyoming are also mounted on Stand I., with plaster casts of the corresponding bones of *Cetiosaurus*

oxoniensis from the Stonesfield Slate near Oxford (the original bones being in the Oxford Museum). A plaster cast of the largest known femur or thigh-bone (*Atlantosaurus immanis*), 6 feet 2 inches in length, from Colorado, is placed on Stand J. *Ornithopsis*, from the English Wealden, is represented in Wall-case 4 by various remains from the Isle of Wight, including fine vertebræ, which display their remarkably light construction resulting from a complicated arrangement of thin

Wall-case 4.
Table-case 15.
Stand J.



a *b*

Fig. 13.—Tooth of a Sauropodous Dinosaur, probably *Ornithopsis hulkei*, from the Wealden of the Isle of Wight, inner (*a*) and outer (*b*) views; nat. size. (Table-case 15.)

struts and plates of bone. A few isolated specimens of the feeble teeth of *Cetiosaurus* and *Ornithopsis* (Fig. 13) are shown in Table-case 15. There are also some bones of allied Sauropoda from Madagascar and Patagonia in Wall-case 4.

SUB-ORDER 2.—**Stegosauria.**

Wall-cases 4, 5. Table-case 16. Case M.

The armoured Dinosaurs or Stegosauria ("plated-lizards") are shown by their teeth to have been herbivorous, and they resemble the next sub-order, Ornithopoda, so closely that they are often grouped with the latter. The latest members of the tribe, discovered in the Upper Cretaceous of Wyoming, are the most heavily built, with a large horned head and a bony frill over the neck (*Triceratops* and *Sterrholophus*, Fig. 14);

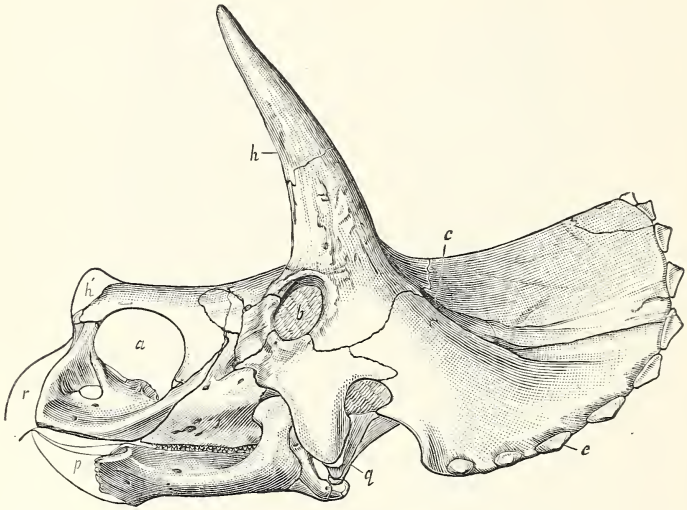


FIG. 14.—Skull and mandible of a horned Dinosaur (*Sterrholophus flabellatus*), left lateral view, from the Cretaceous of Wyoming, U.S.A.; about one-twentieth nat. size. *a.* nostrils; *b.* orbit; *c.* supratemporal vacuity; *e.* small bony plates round the occiput; *h.* the left horn-core of the pair above the eyes; *h.'* horn-core on nose; *p.* predentary bone; *q.* quadrate bone; *r.* rostral bone. (After O. C. Marsh.)

but there are no remains of these reptiles in the Museum. The American Jurassic *Stegosaurus*, with small head, is also well armoured with large bony plates and spines on the trunk. Its skeleton is closely similar to that of *Omosaurus*,

Wall-case 5.

of which fine specimens are exhibited in Wall-case 5. The hip-region and other remains of *Omosaurus armatus*, from the Kimmeridge Clay of Swindon, are especially noteworthy. In the same Wall-case there are also the original specimens of *Hylæosaurus*, obtained by Mantell from the Wealden of

Sussex; and in Wall-case 4 there is another Wealden Stegosaurian, *Polacanthus foxi*, discovered by Rev. W. **Wall-case 4.**

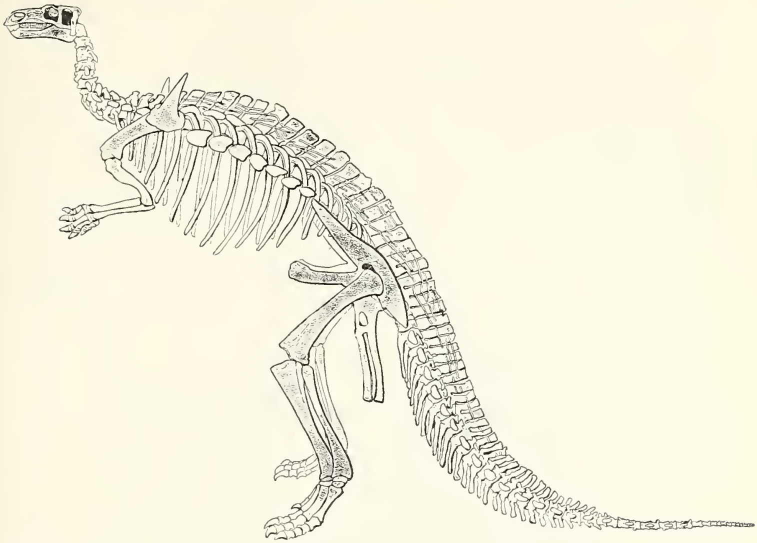


Fig. 15.—Restored skeleton of an armoured Dinosaur (*Scelidosaurus harrisoni*), from the Lower Lias of Charmouth, Dorset; about one-thirtieth nat. size. The figure shows the pair of large spines on the shoulders and a row of smaller spines behind; also the bony tendons crossing and fixing together the neural spines of the vertebræ. (Case M.)

Darwin Fox in Barnes Chine, Brixton, Isle of Wight. The latter specimen lacks the fore-quarters, but shows the paired series of sharply pointed spines on the back, a continuous bony shield over the hip-region ornamented with symmetrically arranged bosses, and another paired series of spines on the slender tail. One of the oldest Stegosauria, *Scelidosaurus harrisoni*, from the Lower Lias of Charmouth, near Lyme Regis, is represented by a nearly complete skeleton in a slab of hard rock in Case M. This reptile (Fig. 15) must have measured about 12 feet in length, and its armour is comparatively feeble. The snout of the long head is broken

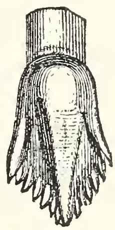


Fig. 16.—A single upper tooth of *Scelidosaurus harrisoni*, from the Lower Lias of Charmouth, Dorset; twice nat. size. **Case M.**

Case M. away from the fossil exhibited, but a few of the teeth (Fig. 16) are preserved in the hinder part of the jaws. Various small fragments of Stegosauria are also placed in Table-case 16.

SUB-ORDER 3.—**Ornithopoda.**

Wall-cases 6a, 6, 7. Table-cases 17, 18. Stands N, O.

The "bird-footed" Dinosaurs, or Ornithopoda, seem to have walked habitually on their hind limbs, which bear much resemblance to those of ostrich-like running birds (Ratitae). They are well represented in the Museum by *Iguanodon* and *Hypsilophodon* from the Wealden and Lower Greensand of the south of England and neighbouring parts of the Continent.

Iguanodon ("iguana-tooth") was named in 1825 by Mantell, who first discovered its teeth (Fig. 17), and

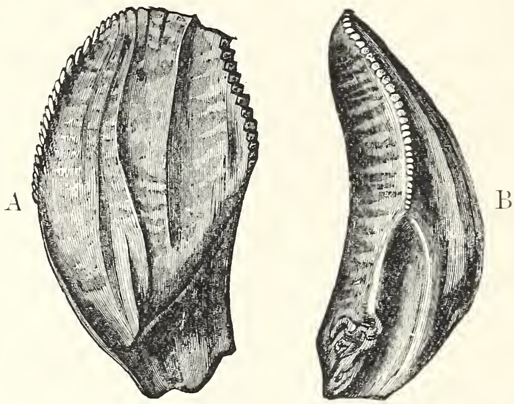


FIG. 17.—Tooth of *Iguanodon*, outer view (A) and side view (B), from the Wealden of Sussex; nat. size. (Table-case 17.)

recognised their close similarity to those of *Iguana*, a lizard now existing in Central America. Some of the actual teeth from the Mantell Collection, exhibited in Table-case 17, show various stages of wear, from the newly-cut crowns to mere flattened stumps, and obviously denote a vegetable-feeder. The earliest-discovered group of bones of the reptile, from Bensted's Kentish Rag quarry at Maidstone, is placed in the centre of Wall-case 7. This specimen was shattered by a shot fired in the hole still seen in the middle of the slab of rock, and the various pieces were collected and re-united with great skill by Mantell, who tried to interpret the bones by comparison with the skeleton of *Iguana*.

Wall-case 7.

Subsequent discoveries, exhibited in Wall-cases 6, 6A, 7, prove that Mantell was misled in several respects, because *Iguanodon* is not in any way closely related to the existing lizards; and a few nearly complete skeletons discovered in the Wealden of Bernissart, near Mons, Belgium, now in the Brussels Museum, show all the principal features of the animal (Fig. 18). These skeletons were found at Bernissart under circumstances which suggest that the individuals they represent met their death by accident in a deep ravine. An exact plaster copy of one of them is placed on Stand O, and its height as mounted is about 14 feet, while its total length **Wall-cases 6, 6a, 7.** **Stand O.**

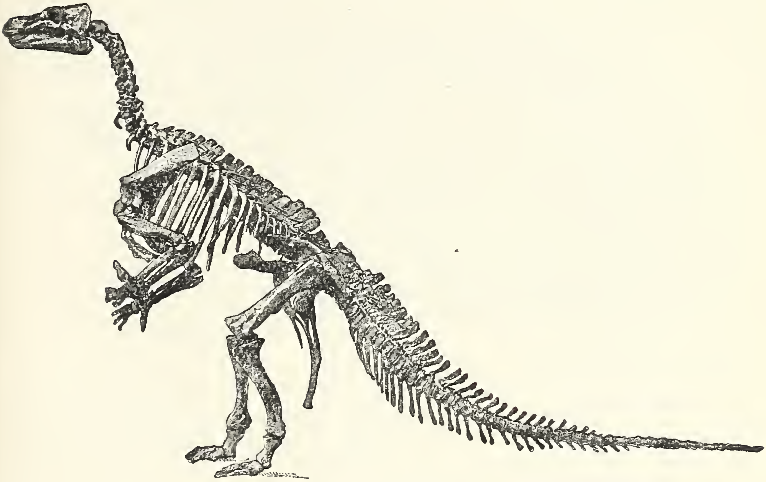


Fig. 18.—Skeleton of an Ornithopodous Dinosaur (*Iguanodon bernissartensis*), from the Wealden of Bernissart, Belgium, as mounted in the Brussels Museum: about one-eightieth nat. size. (Stand O.)

is approximately 25 feet. The large laterally-compressed head (Fig. 19) ends in front in a toothless beak, of which the lower half is supported by a separate "predentary bone." The fore limbs are comparatively small, with slender shoulder blades; and each hand comprises five fingers, though the first of these (or thumb) is reduced to a bony spur, which, when originally found isolated, was supposed by Mantell to have been a horn on the nose. The hip-bones (pelvis) much resemble those of an ostrich in arrangement, but are not fused together as in the Ratite running birds, while a great pubic bone represents a mere knob in the latter. There are

Stand O. only three toes, the basal parts of which are arranged exactly as in young running birds before the parts consolidate (see illustrations of *Dinornis* on Stand O). The tail is deep and laterally compressed, as if for swimming, and both this and the back are strengthened by partially bony tendons lying over the vertebral spines. The three-toed footprints of *Iguanodon* are not uncommon in the Wealden rocks, and are sometimes found in the Purbeck Beds. Examples are shown in Gallery No. 11 (Wall-case 8 and an adjoining stand).

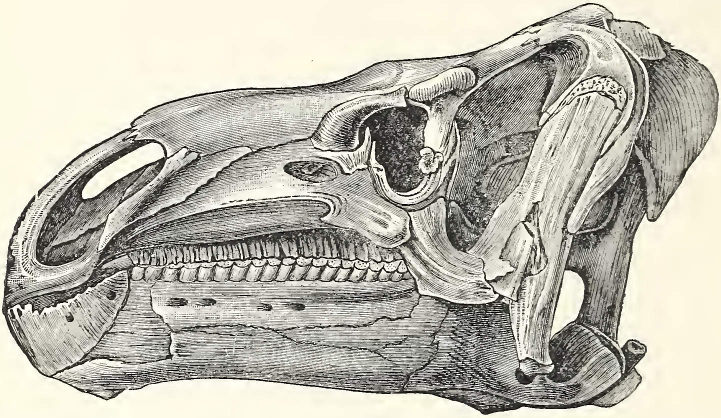


Fig. 19.—Skull and mandible of *Iguanodon bernissartensis*, left side-view, from the Wealden of Bernissart, Belgium; about one-eighth nat. size. The oval nostril is seen in front, the orbit in the face above the hindermost teeth, and the deep and narrow lateral temporal fossa behind. The toothless predentary bone is shown at the front end of the mandible. (After Dollo.)

Stand N. Table-case 18.

Hypsilophodon is a diminutive Iguanodont, of which fine portions of skeletons are exhibited in Wealden sandstone from the Isle of Wight (Stand N and Table-case 18). It has teeth in front of the upper jaw, and its hind feet are four-toed.

Sub-order 4.—**Theropoda.**

Wall-case 8. Table-case 19.

The Theropoda ("beast-footed") are the carnivorous Dinosaurs, with a lightly-constructed skeleton and sabre-like teeth in sockets. Most of them seem to have been shaped like *Iguanodon* and walked on their hind legs; but their hip-bones are different, and more nearly resemble those of the Sauropoda and the crocodiles. They are found in all Mesozoic rocks both in Europe and in North America (Fig.

20), and have also been discovered in South America, South Africa and India, but they are represented in the Museum **Wall-case 8. Table-case 19.**

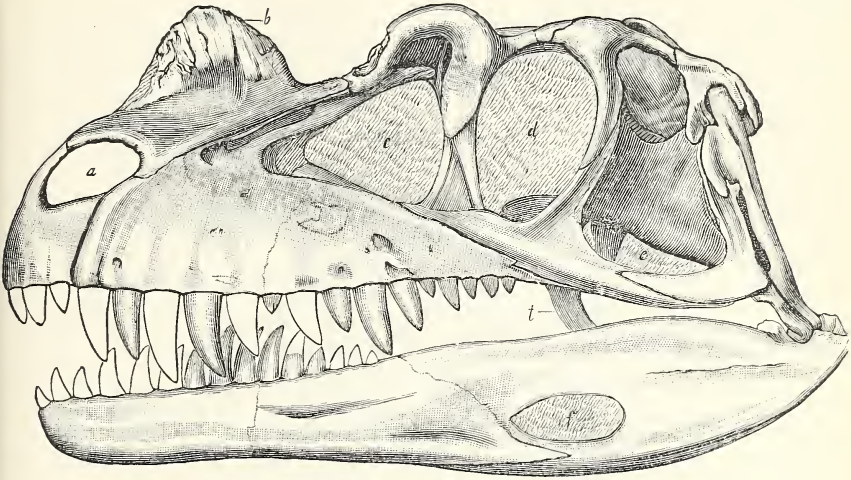


Fig. 20.—Skull and mandible of a Theropodous Dinosaur (*Ceratosaurus nasicornis*), left side-view, from the Upper Jurassic of Colorado, U.S.A.; one-sixth nat. size. *a*. nostril; *b*. horn-core on nose; *c*. preorbital vacuity; *d*. orbit; *e*. lateral temporal fossa; *f*. vacuity in mandible; *t*. transverse bone. (After O. C. Marsh.)

only by fragmentary specimens, and by a plaster cast of one nearly complete small skeleton (*Compsognathus longipes*, from the Lithographic Stone of Bavaria, in Table-case 19). Most of the remains of Theropoda from the English Jurassic and Wealden rocks are referred to *Megalosaurus*, which was first found by Buckland in the Stonesfield Slate, near Oxford (Wall-case 8 and Table-case 19). With *Megalosaurus* are exhibited fragments of *Zanclodon*, *Thecodontosaurus* (Fig. 21), and other genera from the Trias of England and the Continent, and remains of the short-necked *Euskelesaurus* from the Karoo Formation of South Africa. A small carnivorous reptile, *Ornithosuchus*, from the Triassic Sandstone of Elgin, Scotland, seems also to belong to the same group.

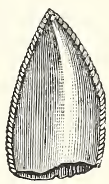


Fig. 21.—Tooth of *Thecodontosaurus platyodon*, from the Upper Trias of Bristol; nat. size. (Table-case 19.)

ORDER V.—RHYNCHOCEPHALIA.

Wall-case 9. Table-case 14.

The little lizard-shaped Tuatera (*Hatteria* or *Sphenodon*), now living on islands off the coast of New Zealand, is the sole survivor of an important group of reptiles which first

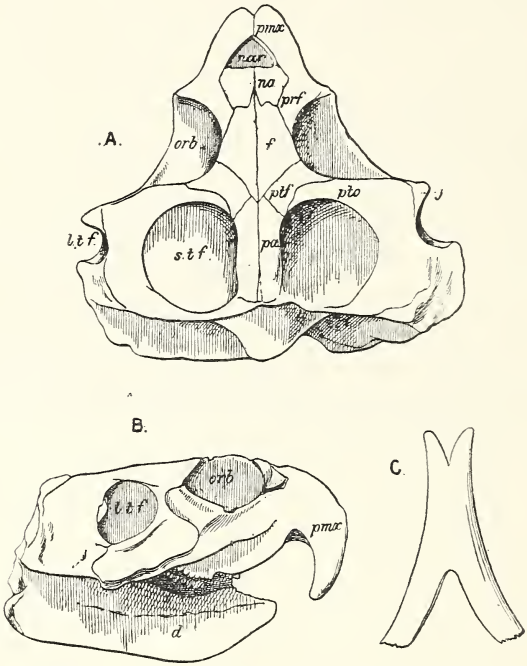


FIG. 22.—Skull and mandible of *Hyperodapedon gordoni;* upper view (A), right side-view (B), and mandibular symphysis from below (C), from the Triassic of Elgin; one-quarter nat. size. *d.* dentary; *f.* frontal; *j.* jugal; *l.t.f.* lateral temporal fossa; *na.* nasal; *nar.* nostril; *orb.* orbit; *pa.* parietal; *pmx.* premaxilla; *prf.* prefrontal; *ptf.* post-frontal; *pto.* postorbital; *s.t.f.* supratemporal fossa. (After A. S. Woodward. Wall-case 9.)

appeared in the Permian period, had a wide distribution in the Triassic period, and still existed both in Europe and North America at least as late as the deposition of the Chalk. These reptiles closely resemble some of the Triassic Theropodous Dinosauria, but their teeth are not fixed in sockets and

Wall-case 9. Table-case 14.

not confined to the edge of the jaw, while the ribs are single-headed. *Proterosaurus* occurs in the Upper Permian of Germany and England, but is only imperfectly known. *Hyperodapedon* (Fig. 22) is Triassic both in Britain and in India, and is represented in Wall-case 9 by a fine skeleton of *H. gordoni* in a slab of sandstone from Elgin, also by fragments from various other localities. *Rhynchosaurus*, from the Trias of Grinshill, Shropshire, is smaller than *Hyperodapedon* and equally well known. There is also a good skeleton of the smaller *Pleurosaurus* from the Upper Jurassic Lithographic Stone of Bavaria.

Dimetrodon and *Naosaurus*, from the Permian of Texas, U.S.A., seem to be Rhynchocephalians, and are remarkable for the length of their vertebral neural spines, which bear lateral processes (Fig. 23).

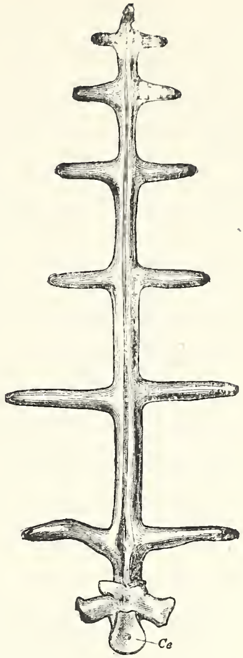


FIG. 23.—Anterior view of a dorsa vertebra of *Naosaurus claviger*, from the Permian of Texas, U.S.A.; one-sixth nat. size. *ce*. centrum or body of vertebra. (Fragments in Table-case 14.)

ORDER VI.—**ANOMODONTIA** or **THEROMORPHA.**

Wall-cases 9, 10. Table-cases 30-33.

The most characteristic reptiles of the Permian and Triassic periods are intermediate in organisation between the early Amphibia and the true Reptilia and Mammalia of later times. They are sometimes named Anomodontia ("irregular toothed"), in allusion to the varied and unusual character of their teeth, while they are sometimes described as Theromorpha ("beast-shaped"), from their evident relationship to the warm-blooded mammals or "beasts." They approach mammals (i.) in the reduced size of the quadrate bone and of the adjoining bones in the lower jaw, (ii.) in the frequently well-formed single bony bar or "malar arch" over the biting

Wall-cases 9, 10. Table-cases 30-33.

muscles of the cheek, (iii.) in the shape of the shoulder-blade, (iv.) in the fusion of the hip-bones into a single innominate bone on each side, (v.) in the presence of a prominent elbow, and (vi.) in the structure of the feet. Their nearest surviving relatives are probably the degenerate Monotreme Mammalia (*Echidna* and *Ornithorhynchus*) of the Australasian region, which have blood less warm than other mammals, possess only incipient milk-glands, and lay eggs.

Numerous remains of Anomodontia have been found in South Africa, India, the European continent (especially Russia), Scotland, and North America. The principal specimens in the Museum were obtained from the Karoo Formation of South Africa, where they were first discovered by Andrew Geddes Bain.

Sub-order 1.—**Theriodontia.**

Table-cases 31, 32. Case R.

The most mammal-shaped of these ancient quadrupeds are those with cutting or piercing front teeth like incisors, with enlarged corner teeth like canines, and with comparatively

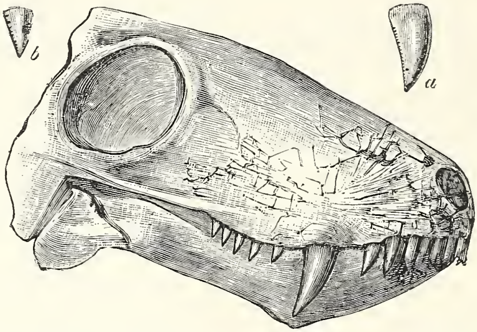


Fig. 24.—Right side-view of skull and mandible of a Theriodont (*Ælurosaurus felinus*), two-thirds nat. size, with two upper teeth, nat. size (*a*, *b*), from the Triassic Karoo Formation of Beaufort West, Cape Colony. Behind the large orbit the back part of the skull is broken away. (After Owen. Table-case 31.)

complex side teeth like premolars and molars. These teeth are, indeed, quite mammalian in appearance (hence the name "Theriodontia" or "beast-toothed"), but they were never replaced during life in the same way as among mammals. They are especially well shown in the fine specimen of *Cynognathus crateronotus* (Case R) obtained by Professor H. G. Seeley

from the Karoo Formation of Cape Colony. The dog-shaped head of this animal is enormous compared with the size of the backbone, which is stiffened by wide overlapping ribs just in front of the hip region. There are two occipital condyles at the back of the skull for union with the backbone, as in the Amphibia and Mammalia. Most of the limb-bones of the fossil have been lost. *Cynognathus*, *Lycosaurus*, *Ælurosaurus* (Fig. 24), and certain other genera (Table-case 31) were doubtless carnivorous; but *Tritylodon* **Table-cases 31, 32. Case R.**

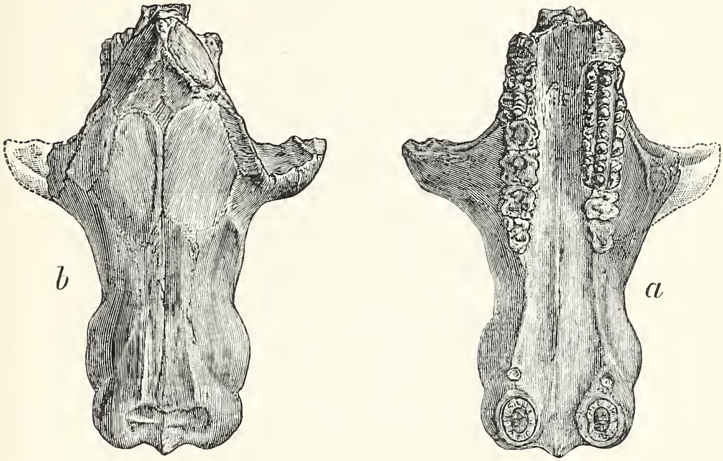


FIG. 25.—Skull of *Tritylodon longævus*, palatal view (*a*) and upper view (*b*), incomplete behind, from the Triassic Karoo Formation of Basutoland; two-thirds nat. size. (Table-case 32.)

(Fig. 25) and its allies (Table-case 32) have grinding teeth as if for a vegetable diet. The remarkably mammalian fore-limb named *Theriodesmus phylarchus* (Table-case 32) belongs to one of the Theriodonts.

SUB-ORDER 2.—**Dicynodontia.**

The Dicynodonts ("double-dog-toothed") have a beak like that of a turtle, but most of them are also provided with a pair of tusks, growing throughout life, at the side of the upper jaw. Their occipital condyle is trefoil-shaped, as in the Chelonia. *Dicynodon* (Fig. 26) occurs in the Karoo Formation of South Africa, and is represented by fine skulls and other remains **Wall-cases 9, 10. Table-case 33.**

Wall-cases 9, 10. Table-case 33. in Wall-case 10 and Table-case 33. *Oudenodon* is a contemporary reptile without tusks. *Gordonia* (Wall-case 9), from the Trias of Elgin, Scotland, has diminutive tusks.

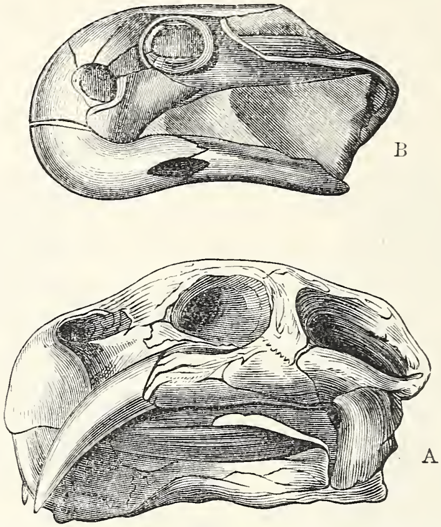
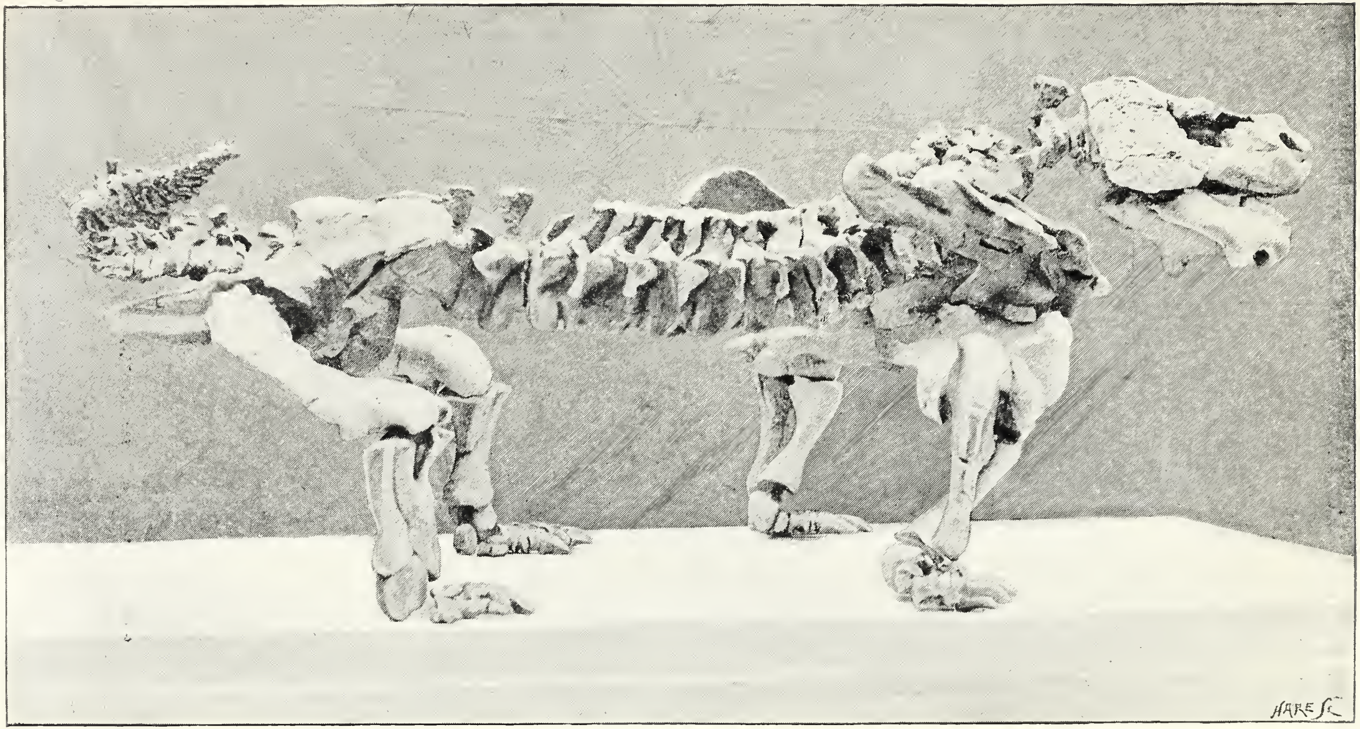


Fig. 26.—Skull and mandible of *Dicynodon lacerticeps* (A) and *Oudenodon baini* (B), left side-view, from the Triassic Karoo Formation of Cape Colony ; one-third nat. size. (Table-case 33.)

Sub-order 3.—**Pariasauria.**

Wall-cases 9, 10. Cases S, T. The Pariasauria are so named from the best-known genus *Pariasaurus* (" helmet-cheek-lizard "), and approach the early Amphibia or Labyrinthodonts more closely than any of the other Anomodontia. The well-preserved skeleton of *Pariasaurus baini* (Plate IV.), discovered by Professor Seeley in the Karoo Formation of Cape Colony, exhibits most of the principal characters of the skeleton (Case T). Other portions of *Pariasaurus* in Case S are also important. The cheek is completely covered with bone, and the pineal foramen for a median eye in the top of the head is especially large. There is only a single occipital condyle. The teeth extend from the margin of the jaw over most of the bones of the palate. Remains of the ribs show that they were single-headed. *Pariasaurus* is a very massive animal, usually from 8 to 10 feet in length, and seems to have been a vegetable-feeder,



Skeleton of an Anomodont Land-Reptile (*Pariasaurus baini*), discovered by Prof. H. G. Seeley in the Karoo Formation of Tamboer Fontein, Cape Colony; about one-fourteenth nat. size. (Case T.)

[To face p. 30.

with limbs almost as completely adapted for digging as those of a mole. It was first found in South Africa, but is now known by many nearly complete skeletons discovered by Professor Amalitzky in northern Russia. Its head-bones are coarsely sculptured, and the head of an apparently allied animal, *Elginia*, from the Trias of Elgin, is not only sculptured, but also armoured with large bony horns or spines (Wall-case 9). **Wall-case 9.**

A diminutive Anomodont, *Procolophon* (Table-case 30), from the Karoo Formation of Cape Colony, exhibits much resemblance to *Pariasaurus*, but may perhaps belong to another sub-order. Its head-bones are not sculptured, and its pineal foramen for the median eye is enormous. A nearly similar animal, *Aristodesmus*, has been found in the Lower Trias of Switzerland. **Table-case 30.**

SUB-ORDER 4.—**Placodontia.**

The skulls named *Placodus* and *Cyamodus* (Fig. 27), from the Muschelkalk (Middle Trias) of the European continent, **Table-case 30.**

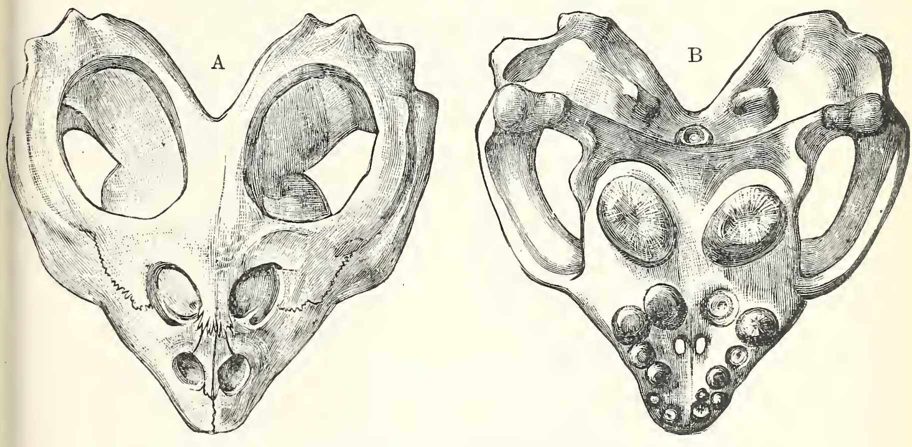


FIG. 27.—Skull of *Cyamodus laticeps*, upper view (A) and palatal view (B), from the Muschelkalk of Baireuth, Germany; one-quarter nat. size. (Table-case 30.)

are very similar in many respects to those of Anomodonts. The vertebræ and limbs of the reptiles to which they belonged are not yet known, but these parts will probably prove to be adapted for life in the sea. The teeth are large grinding

Table-case 30.

plates extending over the palate, and would doubtless be used for crushing shell-fish. Good examples are exhibited in Table-case 30.

ORDER VII.—**SAUROPTERYGIA.**

Wall-cases 11–14. Table-cases 24–29. Cases P, Q.

A group of aquatic reptiles closely related both to the extinct Anomodontia and to the surviving Chelonia was abundantly represented in all the seas of the Mesozoic period. It is known as the Order Sauropterygia ("lizard-finned") because the swimming paddles in all its representatives comprise only the usual four or five reptilian toes, which are not supplemented by other little bones as in the paddles of the contemporary Ichthyopterygia (see p. 37).

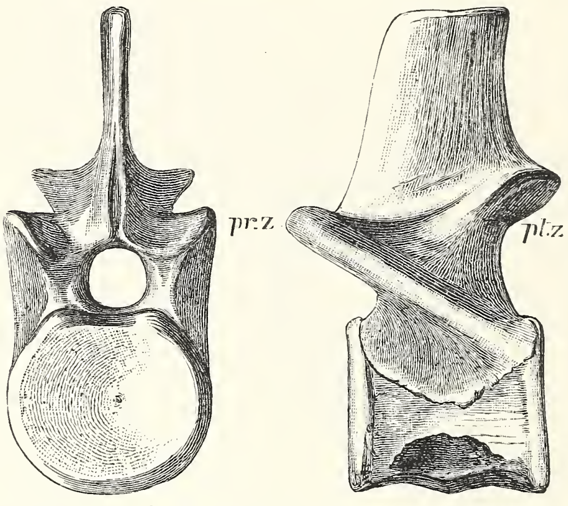
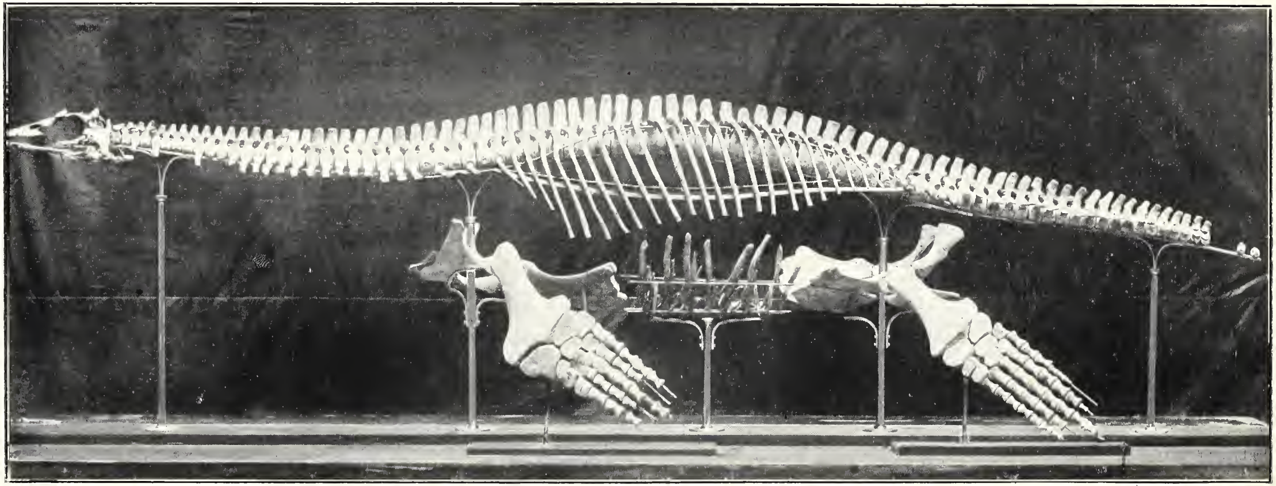


FIG. 28.—Hinder neck-vertebra of *Plesiosaurus*, front and side views, from the Lower Lias of Lyme Regis; two-thirds nat. size. *pr.z.* prezygapophysis; *pt.z.* postzygapophysis. (Table-case 27.)

Cases P, Q.

The general characters of the Order are especially well shown by the skeletons of *Cryptoclidus* in Cases P, Q, while more technical points are illustrated in Table-cases 24 to 29. The head varies in size, but is usually small, and the conical teeth are fixed in deep sockets round the margin of the jaws. The vertebræ (Fig. 28) are slightly biconcave. Although the neck is always distinct and often long and slender, it must have



Skeleton of a Plesiosaurian Marine Reptile (*Cryptoclidus oxoniensis*), discovered by Mr. Alfred N. Leeds in the Oxford Clay near Peterborough; about one-twentieth nat. size. (Case Q.)

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been almost inflexible, and could not have assumed the graceful **Cases P, Q.** curves usually ascribed to it in fanciful restorations. The body is barrel-shaped, and its lower face, between the ends

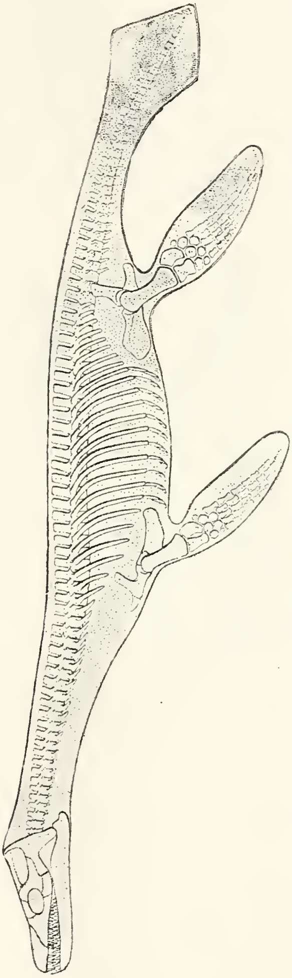


Fig. 29.—Skeleton of *Plesiosaurus macrocephalus*, with outline of body and tail-fin indicated in shading, from the Lower Lias of Lyme Regis; about one-eighteenth nat. size. The tail-fin has only been seen in one specimen of another species, now in the Royal Museum of Natural History, Berlin.

of the ribs, is strengthened not only by the expanded plates of bone which support the paddles, but also by many intervening rows of abdominal ribs. The tail is quite short, and is known to have been provided with a small rhomboidal

Cases P, Q. fin-membrane extended in a vertical plane (Fig. 29). The joints (phalanges) of the toes which form the paddles are more numerous than usual, as in the modern whales and porpoises. There is no trace of armour.

Table-case 26. The latest Sauropterygia of Cretaceous age seem to have been world-wide in distribution, but are illustrated in the collection only by fragments. Among these the powerful teeth of *Polyptychodon* (Fig. 30), from the Chalk, Greensand, and Gault, are noteworthy (Table-case 26). In the Upper Jurassic there are the large-headed short-necked Pliosauria, besides the small-headed long-necked Plesiosauria. *Pliosaurus* itself must have been a gigantic reptile, the skull and

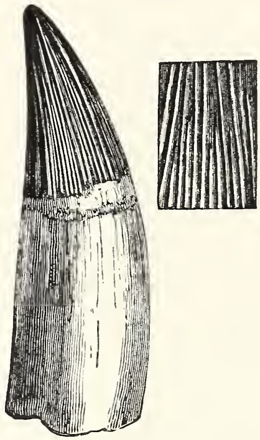


FIG. 30.—Tooth of *Polyptychodon interruptus*, from the Cambridge Greensand; one-half nat. size. A portion of the ribbed enamel of the crown is shown on the right, nat. size. (Table-case 26.)

Wall-case 10. jaws of *P. grandis*, from the Kimmeridge Clay, measuring 6 feet in length, while those of *P. ferox*, from the Oxford Clay, are not much smaller (Wall-case 10). *Peloneustes* (Fig. 31, A), with a slender snout, is an allied animal from the Oxford Clay. *Cryptoclidus* (Plate V.), well represented by the two skeletons from the Oxford Clay of Peterborough already mentioned (Cases P, Q), does not differ much from the Liassic *Plesiosaurus* (Fig. 29), except in the relations of the bones supporting the fore limbs. *Plesiosaurus* and

Wall-cases 11–14. closely similar genera from the English Lias are represented by a unique series of skeletons in Wall-cases 12, 13, 14. The plaster cast of a partially restored skeleton of

Plesiosaurus cramptoni, from the Upper Lias of Whitby (original in National Museum, Dublin), shows the large size sometimes attained. This specimen (Wall-case 13) measures 22 feet in length, and the span to the tip of the paddles is 14 feet. **Wall-case 13.**

The Triassic Sauropterygia comprised not only typical **Table-cases 24, 25.**

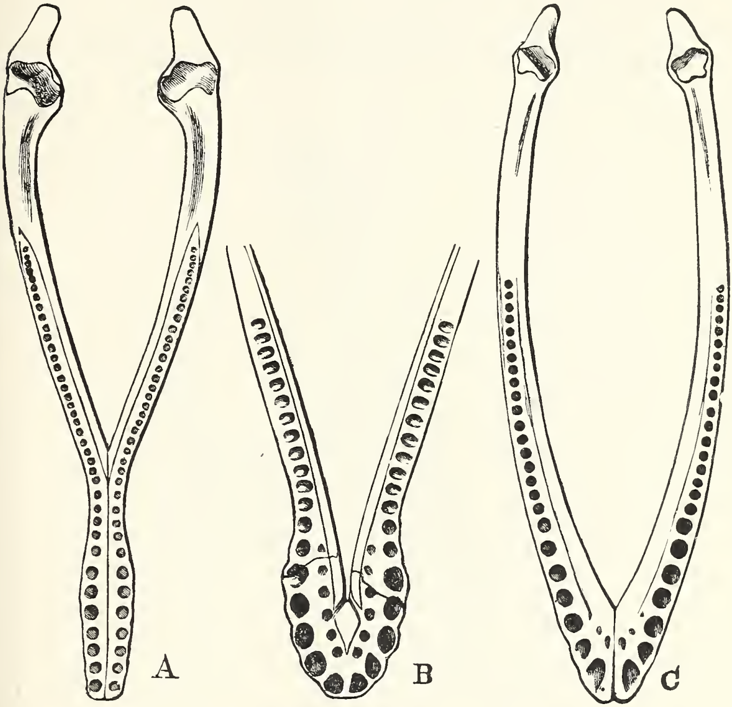


FIG. 31.—Mandibles of Sauropterygia, upper view, without teeth. (A) *Peloneustes philarchus*, from the Oxford Clay of Peterborough; one-eighth nat. size. (B) *Thaumatosaurus indicus*, from the Upper Jurassic of India; one-seventh nat. size. (C) *Plesiosaurus dolichodeirus*, from the Lower Lias of Lyme Regis; one-quarter nat. size.

aquatic reptiles such as *Nothosaurus* (Fig. 32) and *Pistosaurus* from the German and Italian Muschelkalk (Table-cases 24 and 25), but also smaller reptiles with limbs less completely adapted for swimming. These are commonly regarded as the ancestors of the Plesiosaurs, and as proof that they were descended from land animals. *Lariosaurus* (Fig. 33) and

Table-cases 24, 25. *Neusticosaurus* (Table-case 24) are typical examples, while

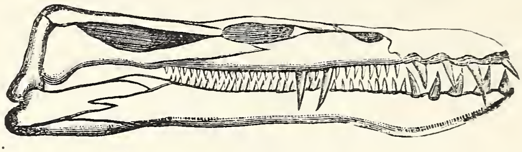


FIG. 32.—Skull and mandible of *Nothosaurus mirabilis*, right side-view from the Muschelkalk of Germany; one-sixth natural size. (Table-case 24).

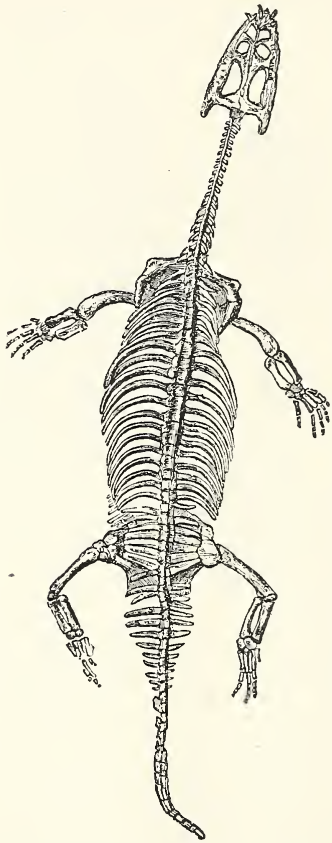


FIG. 33.—Skeleton of an early Sauropterygian (*Lariosaurus balsami*), from the Muschelkalk of Perledo, Como, Italy; one-eighth nat. size. Original in Munich Museum; plaster cast on wall near Table-case V.

the small *Mesosaurus* from South Africa and Brazil seems to be a close ally.

ORDER VIII.—**ICHTHYOPTERYGIA**.

Fish-shaped or porpoise-shaped aquatic reptiles lived with the Sauropterygia and were equally cosmopolitan. **Wall-cases 15–17. Stands A–C. Case H.**

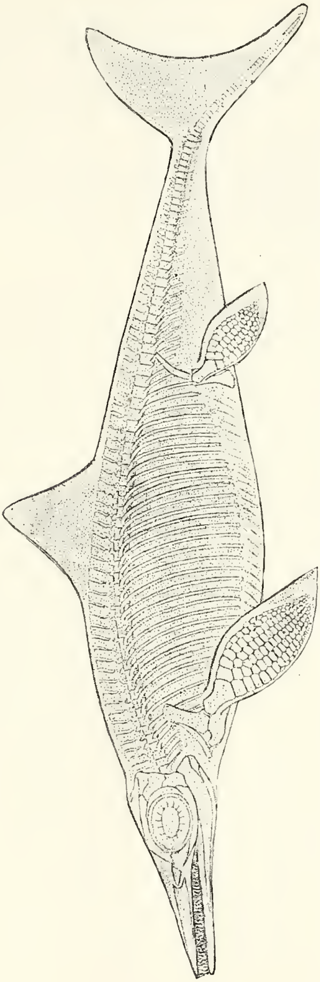


FIG. 34.—Skeleton of *Ichthyosaurus communis*, with outline of body and fins indicated in shading, from the Lower Lias of Lyme Regis; about one-thirtieth nat. size. (Wall-case 17.)

They form the Order of Ichthyosauria ("fish-lizards") or Ichthyopterygia ("fish-finned"), and the toe-bones in the paddles are not only pressed together into a mosaic, but are

Wall-cases 15–17. Stands A–C. Table-cases 20–23. Case H.

also supplemented by other small bones (Fig. 38). These reptiles (Fig. 34) are well illustrated by a unique collection

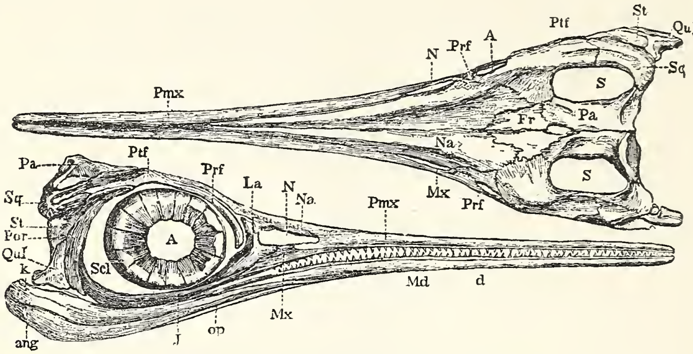


FIG. 35.—Skull and mandible of *Ichthyosaurus zetlandicus*, from the Upper Lias of Normandy; about one-quarter nat. size. *A*. orbit; *ang*. angular; *d*. dentary; *Fr*. frontal; *J*. jugal; *k*. articular; *Md*. mandible; *Mx*. maxilla; *N*. nares; *Na*. nasal; *op*. splenial; *Pa*. parietal; *Pmx*. premaxilla; *Por*. postorbital; *Prf*. prefrontal; *Ptf*. postfrontal; *QuJ*. quadratojugal; *S*. supratemporal fossa; *Scl*. sclerotic ring; *Sq*. squamosal; *St*. supratemporal. (After Zittel. Table-case H.)

of skeletons, chiefly from the English Lias, in Wall-cases 15, 16, 17, and by smaller fragments in Table-cases 20 to 23. The large head (Fig. 35) is shaped like that of a porpoise, with an elongated snout and with powerful conical teeth (Fig. 36) set in a groove along the edge of the jaw. The nostril is just in front of the enormous eye, and this is strengthened by a ring of sclerotic plates which would help in focussing for varying distances. There is a conspicuous pineal foramen for a median eye in the top of the head (see skull in Table-case 21). The vertebræ (Fig. 37), which are very numerous, short, and biconcave, are shaped like those of a fish to insure flexibility of the backbone. The neck is quite short, while the vertebræ of the tail are sharply turned down at some distance from the end, to support a triangular vertical

FIG. 36.—Tooth of *Ichthyosaurus campylodon*, from the Lower Chalk of Folkestone; nat. size. (Table-case 20.)

Table-case 20.

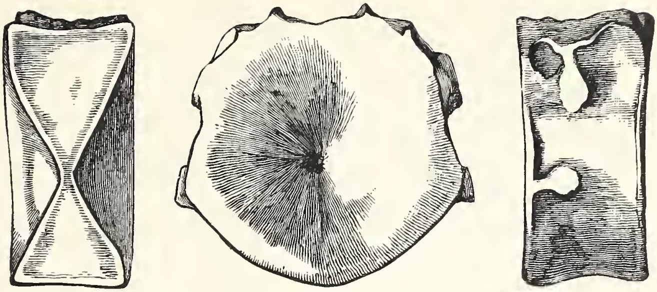


FIG. 37.—Body or centrum of anterior dorsal vertebra of *Ichthyosaurus*, viewed in section, from the front and from the left side; from the Kimmeridge Clay of Wiltshire; one-half nat. size. (Table-case 20.)

Table-case 21.

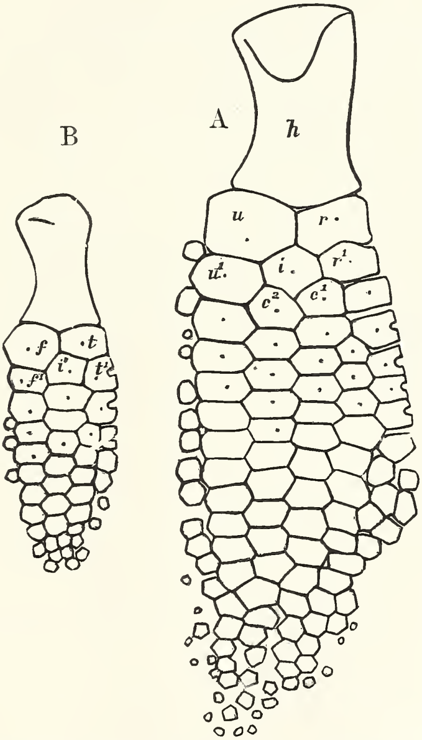


FIG. 38.—Right fore (A) and hind (B) paddles of *Ichthyosaurus intermedius*, from the Lower Lias of Lyme Regis; one-third nat. size. c^1, c^2. centralia; *f*. fibula; f^1. fibulare; *h*. humerus; *i*. intermedium; *r*. radius; r^1. radiale; *t*. tibia; t^1. tibiale; *u*. ulna; u^1. ulnare. (After Lydekker.)

Wall-cases 15–17. Stands A–C. Table-cases 20–23. Case H.

tail-fin, which has been seen in a few well-preserved specimens from the German Lias and Lithographic Stone (not in the Collection). Both pairs of paddles (Fig. 38) are always present, but the hinder pair is often small. The skin must have been quite smooth, without armour, and it is shown in some German specimens (not in the Collection) to have formed a smooth triangular fin in the middle of the back, as in modern porpoises.

The small Triassic Ichthyosaurs, of which there are no specimens in the Museum, suggest that they, like the Plesiosaurs, were descended from land animals. In some important respects the skull and teeth resemble those of the Labyrinthodont Amphibia (p. 47). The Liassic Ichthyosaurs, of which a fine series is exhibited in Wall-cases 15, 16, 17, are typical members of the Order and sometimes attain a very large size. The skeleton of *Ichthyosaurus platyodon*, from the Lower Lias of Stockton, Warwickshire, presented by Mr. Michael H. Lakin, measures 22 feet in length; while vertebræ at the bottom of the same Wall-case and skulls in Gallery 3 (pedestals lettered A, B, C) belong to much larger individuals. A nearly complete small skeleton from the Lower Lias of Street, Somersetshire (Plate VI.), is an especially good example of a slender-nosed species (Wall-case 15). An equally good specimen of an allied species from the Upper Lias of Würtemberg, at the bottom of the same Wall-case, is interesting as showing six embryos within the ribs, proving that these reptiles were viviparous. Two fragments from the Lower Lias of Barrow-on-Soar, Leicestershire (Wall-case 17 and Table-case 21), exhibit the fin-membrane round the bones of the fore-paddle.

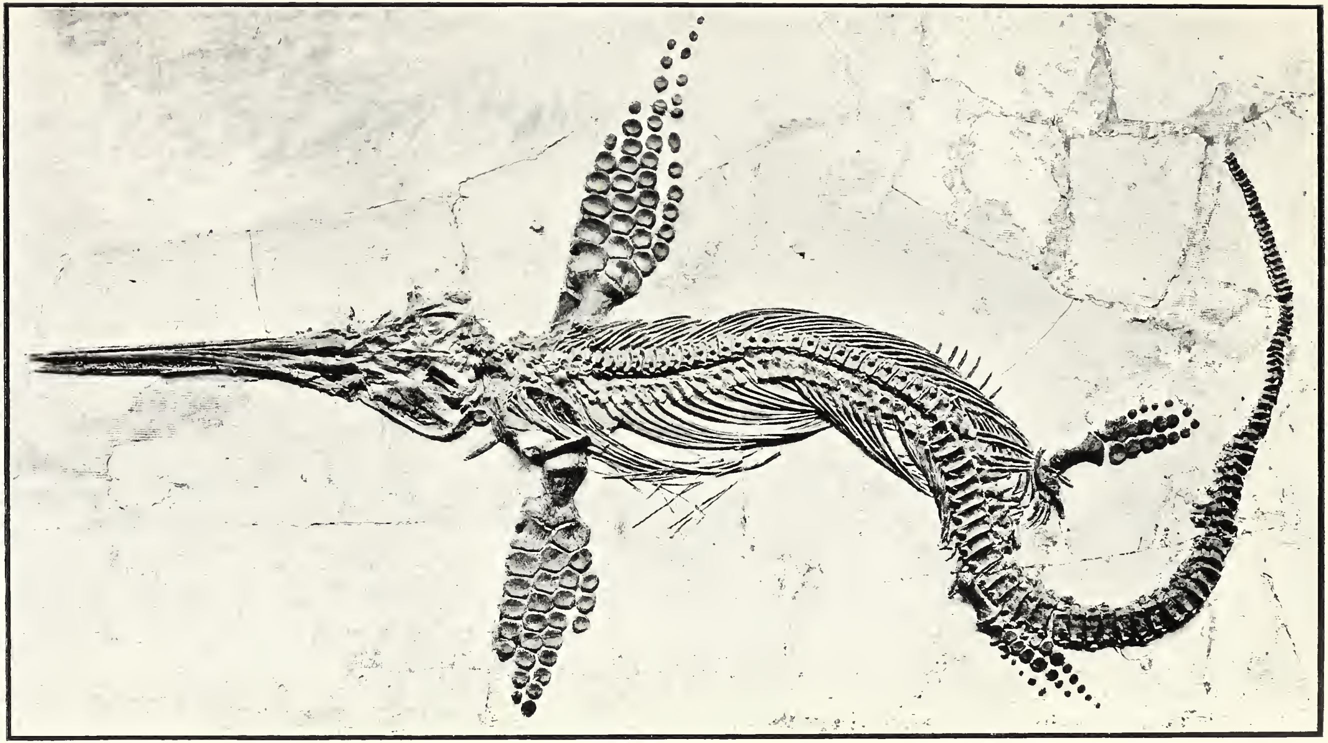
Wall-case 16.

Typical Ichthyosaurs seem to have ranged upwards to the Chalk, and fragmentary remains of the later species are exhibited in Table-case 20. Some of the Upper Jurassic genera, however, both in Europe and in North America, are almost toothless and have broad paddles, which must have been rendered very flexible by a persistent rim of cartilage round each of the constituent bones. *Ophthalmosaurus* is a typical and well-known example from the Oxford Clay of Peterborough (Table-case 23).

Table-case 20.

Case G.

Coprolites, or pieces of fossilised excrement, are often found in the Lias where remains of Plesiosaurs and Ichthyosaurs occur, and were probably left by these reptiles. A collection is exhibited in Table-case G. They contain numerous scales of ganoid fishes which have been eaten, and



Skeleton of a Marine Ichthyosaurian (*Ichthyosaurus tenuirostris*) from the Lower Lias of Street, Somersetshire; about one-eleventh nat. size. (Wall-case 15.)

[*To face p.* 40.

many of them are marked by a spiral line, which bears witness to the spiral form of the membrane in the intestine through which they originally passed. Case G.

ORDER IX.—CHELONIA.

The tortoises and turtles date back to the Triassic period, when they seem to have already assumed their most Wall-cases 18, 19. Cases W to Z.

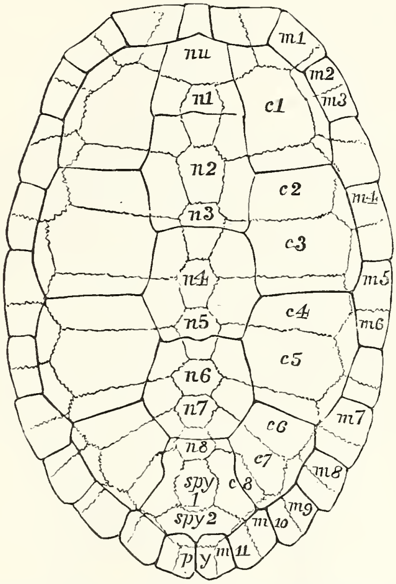


FIG. 39.—Carapace or dorsal shield of a small Tortoise (*Hardella thurgi*), from the Pliocene of the Siwalik Hills, India; reduced in size. The wavy lines show the divisions (or sutures) between the bones; the firm lines indicate those between the overlying horny shields. *c*. 1–8, costal bones; *m*. 1–11, marginal bones; *n*. 1–8, neural bones; *nu*. nuchal bone; *py*. pygal bone; *spy*. 1, 2, suprapygal shields. (After Lydekker.)

characteristic features. Fragments of a typical Chelonian shell (*Chelytherium obscurum*) are exhibited from the Keuper Sandstone near Stuttgart, Germany. Wall-case 19.

SUB-ORDER 1.—Trionychia.

The three-clawed mud-turtles appear with all their typical characters in the Eocene both of Europe and North America. Wall-case 18.

Well-preserved shells and other remains of *Trionyx* from the Upper Eocene of Hampshire are exhibited in Wall-case 18.

Sub-order 2.—**Cryptodira.**

Wall-cases 18, 19. Cases W to Z.

Most of the known extinct Chelonia, like the majority of existing tortoises and turtles, belong to the sub-order Crypto-

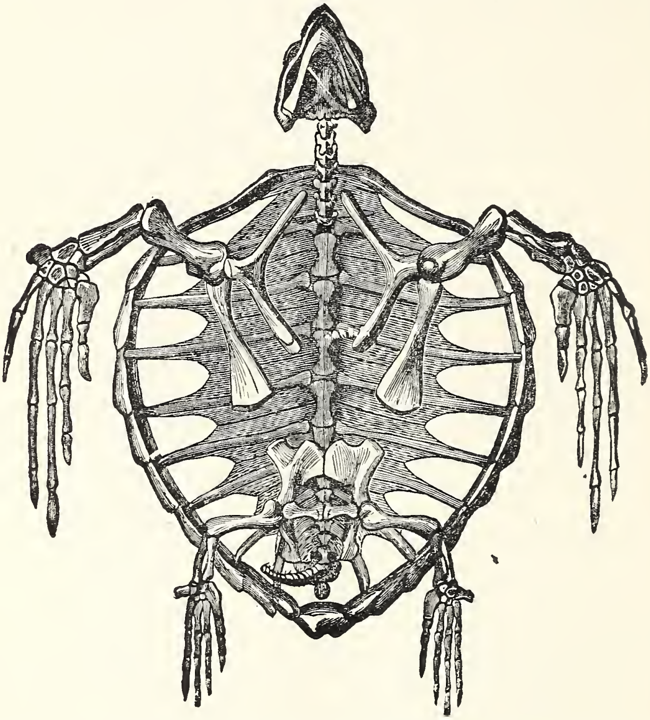


Fig. 40.—Lower view of the skeleton of the existing Logger-head Turtle (*Thalassochelys caretta*); much reduced in size.

dira ("hidden-necked"), in which the head is retracted by curvature of the neck in a vertical plane. The pelvis in these reptiles is not directly connected with the ventral armour or plastron.

The ordinary marsh and land tortoises first occur in Eocene rocks, where modern kinds are associated with several extinct genera. Typical specimens are shown from the

London Clay of Sheppey in Table-case W. Large tortoises (*Testudo ammon*) are also exhibited from the Upper Eocene of Egypt (Wall-case 19); and there are still larger specimens (*T. grandidieri*) from caverns in Madagascar (Stands Y, Z). The largest known tortoise is *Colossochelys atlas*, from the Lower Pliocene of the Siwalik Hills, India, represented by fragments in Wall-case 18, and by a restored model of the shell (Stand X), which measures 8 feet in length. Like all other tortoises, this must have been a vegetable-feeder. The **Wall-cases 18, 19. Cases W to Z.**

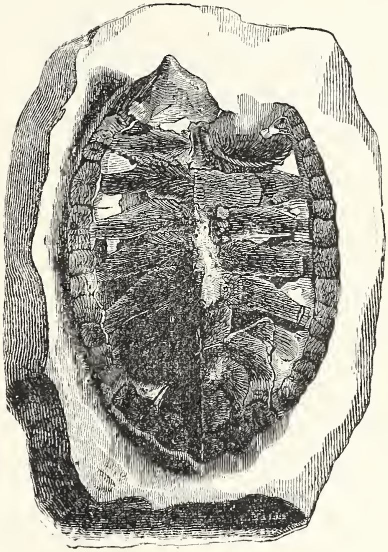


FIG. 41.—Carapace or dorsal shield of a small Turtle (*Chelone benstedi*) from the Lower Chalk of Burham, Kent; about one-third nat. size. (Wall-case 18.)

last survivor of the tortoises in England was *Emys orbicularis*, of which shells have been found in Pleistocene deposits in Norfolk. This species still survives in southern Europe.

The earliest typical turtles are of Cretaceous age, and fine specimens of the large *Chelone hoffmanni* are exhibited from the Upper Chalk of Maastricht, Holland (Wall-case 18). Fragments of similar turtles, with remains of smaller species such as *Chelone benstedi* (Fig. 41), also occur in the English Chalk. Skulls of *Rhinochelys* are common in the Cambridge Greensand. A gigantic leathery turtle, *Eosphargis gigas*, is **Wall-case 18.**

Wall-case 18. represented by a well-preserved skull and other remains from the London Clay of Sheppey. There are also small species of extinct genera of true turtles in the same formation (*e.g.*, *Argillochelys*).

The fresh-water *Chelydra*, now confined to the warmer parts of the New World, has been discovered in the Upper Miocene of Oeningen, Baden (Wall-case 18).

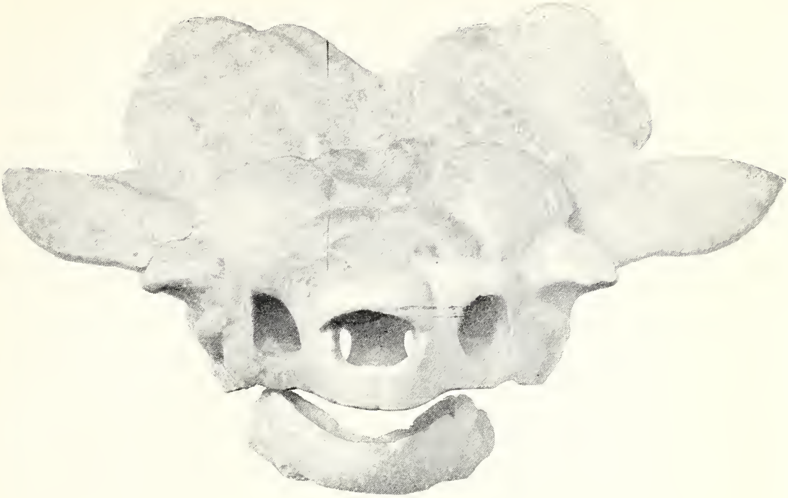
SUB-ORDER 3.—**Pleurodira.**

Wall-case 19. The existing Chelonia which withdraw their head by bending the neck sideways to rest within the margin of the shell, are now confined to the southern hemisphere; but in Tertiary times they were also common in the northern hemisphere. Various fragmentary remains, including shells of *Podocnemys* from the Eocene of Egypt, are exhibited in Wall-case 19. The most noteworthy extinct genus is the horned *Miolania*, which occurs not only in the Pleistocene of Queensland (Plate VII.) and Lord Howe's Island (400 miles distant from the Australian coast), but also in rocks of uncertain age in Chubut, north of Patagonia (Plate VII.). The tail in this reptile is armoured with thick bony rings like those of the extinct South American armadillo, *Glyptodon*. As *Miolania* must have been a land-animal, its discovery in regions so remote as Australia and South America is sometimes cited as one proof of the former existence of a great Antarctic continent uniting the lands in question.

SUB-ORDER 4.—**Amphichelydia.**

Wall-case 19. Most of the Jurassic and Wealden Chelonia are somewhat intermediate between the Cryptodira and Pleurodira, and have been provisionally placed in a separate sub-order. Among typical examples may be mentioned *Pleurosternum* from the Purbeck Beds of Swanage and *Platychelys* from the Lithographic Stone (Kimmeridgian) of Bavaria (Wall-case 19).

A



B

SKULLS OF TWO SPECIES OF A HORNED TORTOISE (MIOLANIA).

A. *Miolania argentina*, from the supposed Cretaceous of Chubut, Patagonia.
B. *Miolania oweni*, from the Pleistocene of Queensland. (Wall-case 19.)

[*To face p.* 44.

GALLERIES Nos. 4, 5.—FOSSIL AMPHIBIANS.

The frogs, newts, salamanders and their allies are intermediate in all essential respects between reptiles and fishes. It is therefore interesting to note that the Class Amphibia, to which they belong, attained most importance in Carboniferous and Permian times, between the Devonian period, when fishes were the highest kind of life, and the Triassic period, when the "Age of Reptiles" dawned. Since Triassic times, indeed, the Amphibia seem to have been degenerate and insignificant animals, and the geological record is so incomplete that it furnishes none of the links connecting these later Orders with the Order which represented the Class in its prime. **Wall-case 19. Table-cases U, V.**

Class IV.—AMPHIBIA.

Order I.—**ANURA** or **ECAUDATA.**

The frogs and toads, or tailless Amphibians, seem to have undergone scarcely any essential change since the Eocene and Oligocene periods. Fine specimens both of adult individuals and tadpoles are exhibited from the Lower Miocene lignite of Rott, near Bonn, and impressions of the soft parts often surround the fossils. *Palæobatrachus* is an extinct toad representing a family intermediate between certain existing groups. **Table-case U.**

Order II.—**URODELA** or **CAUDATA.**

The newts and salamanders have also changed but little since the Eocene and Oligocene periods. They are proved, indeed, to date back to the end of Jurassic times by a single skeleton (*Hylæobatrachus croyi*) from the Wealden of Bernissart, Belgium, now in the Brussels Museum. Newts are exhibited from the Lower Miocene of Rott, near Bonn, and **Wall-case 19. Table-case U.**

Wall-case 19. Table-case U.

among the salamanders there is a large specimen of *Cryptobranchus scheuchzeri* (Fig. 42) from the Upper Miocene of Oeningen, Baden, in Wall-case 19. This gigantic salamander is closely related to a species still surviving in Japan.

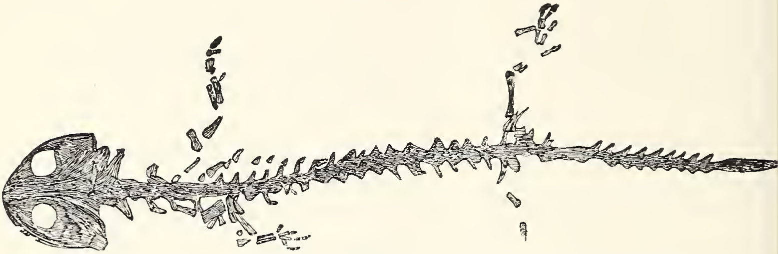


Fig. 42.—Skeleton of a gigantic Salamander (*Cryptobranchus scheuchzeri*) from the Upper Miocene of Oeningen, Baden; one-tenth nat. size. "Homo diluvii testis" of Scheuchzer. (Wall-case 19.)

Another specimen of the same animal, now in the Teyler Museum, Haarlem, was mistaken for a human skeleton by Scheuchzer, who described it in 1726 as *Homo diluvii testis*—"man a witness of the deluge."

Order III.—STEGOCEPHALIA.

Wall-case 19. Table-cases U, V.

As already mentioned, the most important Amphibians are those which flourished in the Carboniferous and Permian periods, and disappeared at the end of the Trias. They must have resembled crocodiles and salamanders in outward appearance, and they are known as Stegocephalia ("roofed-heads"), because the space for their biting muscles is always roofed by plates of bone, arranged much like those of the contemporary paddle-finned fishes. The skull is nearly always pitted or sculptured like that of a crocodile, and is marked with symmetrically-arranged grooves for slime-canals. There is always a pineal foramen. The palate resembles that of the modern Amphibia, and, as in the latter, the skull is fixed to the backbone by a pair of occipital condyles. The clavicles and interclavicle are expanded into large breast-plates, which are usually sculptured; and behind these there is nearly always an armour of small bony scales arranged in a chevron pattern.

Remains of Stegocephalia are found in nearly all parts of the world, including Australia.

SUB-ORDER 1.—**Labyrinthodontia.**

The largest and most typical Stegocephalia possess powerful conical teeth, which are curiously complicated in structure. Each tooth is a hollow cone, with the wall folded inwards in numerous vertical pleats, which are crumpled where crushed together. In allusion to this peculiarity, which is well shown by a tooth of *Mastodonsaurus* in Table-case V, the animals are named Labyrinthodontia ("labyrinth-toothed"). **Wall-case 19. Table-case V.**

The largest Labyrinthodonts are those from the Upper

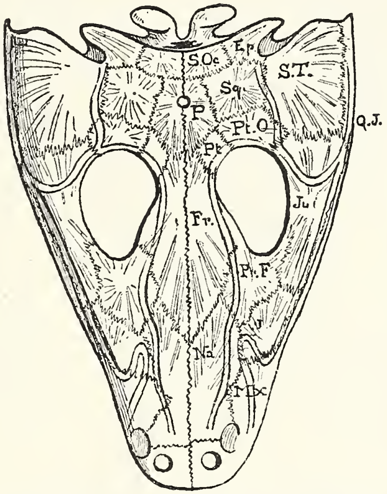


FIG. 43.—Skull of *Mastodonsaurus giganteus*, upper view with sculpture omitted, from the Lower Keuper of Würtemberg; about one-eighth nat. size. *Ep.* lateral supratemporal; *Fr.* frontal; *Ju.* jugal; *L.* lachrymal; *Mx.* maxilla; *Na.* nasal; *P.* parietal; *Pr.f.* prefrontal; *Pt.* postfrontal; *Pt.o.* postorbital; *Q.J.* quadratojugal; *S.T.* prosquamosal; *S.Oc.* inner supratemporal; *Sq.* squamosal. The double lines indicate slime-canals. (After E. Fraas.)

Trias of Würtemberg referred to *Mastodonsaurus*. The skull of *M. giganteus* (Fig. 43) sometimes measures 4 feet in length. A plaster cast of a smaller skull is exhibited in Wall-case 19, and fragments of actual bones and teeth of the same genus are placed in Table-case V. *Capitosaurus* is another well-known Triassic genus, comprising species of smaller size, represented in Wall-case 19, not only by skulls from Germany, but also by a well-preserved skull from the Keuper Sandstone of Stanton, near Uttoxeter, North Staffordshire.

Wall-case 19. Table-case V.

Metoposaurus, from the Trias of Würtemberg, has the eyes far forward in the head. *Rhytidosteus* and *Bothriceps* (Fig. 44), from the Trias of South Africa and Australia (Table-case V), are also noteworthy.

The Permian Labyrinthodonts in the collection belong chiefly to *Archegosaurus* and *Actinodon,* and are interesting as showing parts of the body and limbs. The remains of *Archegosaurus decheni,* in nodules from the Lower Permian of Rhenish Prussia, are especially well preserved. The backbone is incompletely formed, each vertebra consisting of three or more pieces, surrounding a large persistent strand of noto-

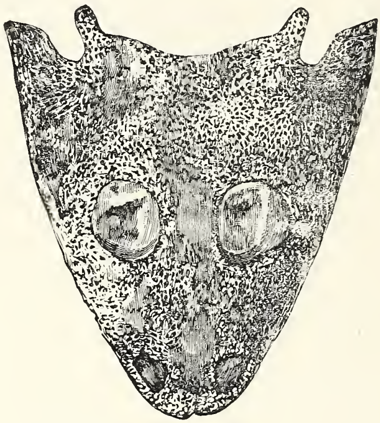


Fig. 44.—Skull of *Bothriceps huxleyi,* upper view, from the Triassic Karoo Formation of Orange River Colony, South Africa; four-fifths nat. size. (Table-case V.)

chord, much like the vertebra of *Euchirosaurus* from France (Fig. 45), and that of *Eryops,* from Texas, in Table-case V. The ribs are short, and evidently did not completely encircle the trunk, so that in breathing the animal must have swallowed air like a frog. The ends of the limb-bones were originally cartilaginous, and hence are not preserved in the fossils. Traces of gill-arches can sometimes be seen in young specimens, proving that *Archegosaurus* resembled modern Amphibia in breathing by gills during the earlier part of its life.

Among the remains of Carboniferous Labyrinthodonts an uncrushed skull of *Loxomma,* obtained by Mr. George Maw from ironstone in the Coal Measures of Coalbrookdale, is particularly interesting (Wall-case 19). Owing to their

imperfect ossification, nearly all the skulls of these animals are flattened by pressure in the rocks. Other remains of *Loxomma* and *Anthracosaurus* are exhibited from the English Coal Measures, and these include short biconcave vertebræ which resemble those of *Ichthyosaurus*, except that they are

Wall-case 19. Table-case V.

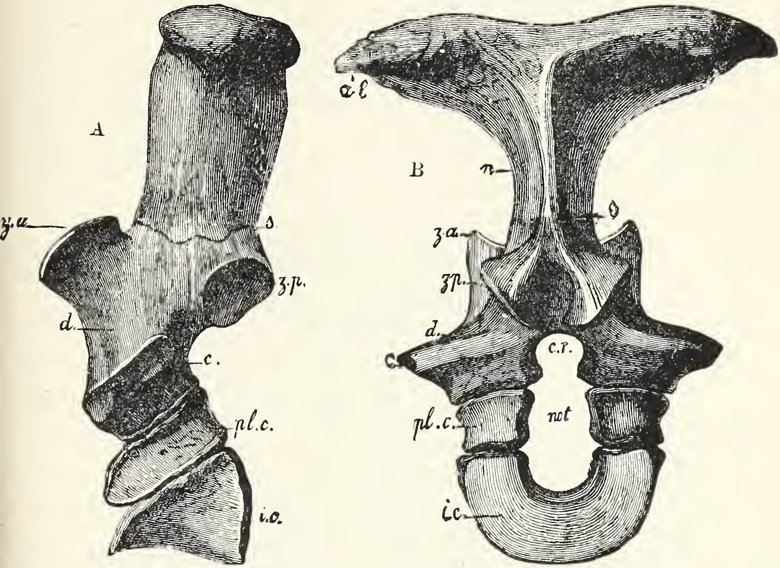


FIG. 45.—Vertebra of *Euchirosaurus rochei*, left lateral (A) and posterior (B) views, from the Lower Permian of France; about nat. size. *al.* lateral expansion of neural arch; *c.* facette for rib; *c.r.* neural canal; *d.* transverse process of neural arch; *ic.* hypocentrum or intercentrum; *n.* neural spine; *not.* space originally occupied by notochord; *pl.c.* pleurocentra; *s.* suture between neural arch and spine; *z.a.*, *z.p.*, anterior and posterior zygapophyses. (After A. Gaudry.)

pierced by a hole for a remnant of the notochord. In Wall-case 19 there is also an incomplete skeleton of *Pholidogaster* from the Lower Carboniferous of Scotland. The limbs of the Lower Carboniferous Labyrinthodonts are unknown.

SUB-ORDER 2.—**Microsauria.**

In Upper Carboniferous and Lower Permian rocks there are remains of numerous small lizard-shaped Stegocephalia, named Microsauria ("little lizards"), which are in some respects intermediate between the Amphibia and the true Reptilia.

Wall-case 19. Table-case U.

Wall-case 19. Table-case U. The skull is typically Stegocephalian, with two bony occipital condyles, and with the teeth comparatively simple in structure. The vertebræ are constricted cylinders, and the ribs are sometimes as long and slender as in a lizard.

Remains of Microsauria were first discovered inside decayed tree-stumps in the Coal Measures of South Joggins, Nova Scotia, where the little animals had evidently been trapped by accident. Numerous skeletons have since been found in Coal Measures of other localities both in North America and Europe and in the Lower Permian Coal Measures of Bohemia. Some of the original bones of *Hylonomus* discovered by Sir William Dawson in the decayed trees in Nova Scotia are exhibited in Table-case U. Specimens of *Ceraterpetum* are also shown from the Coal Measures of Kilkenny and Staffordshire; and there are electrotypes of this and several other kinds from the Lower Permian of Bohemia. Most of the Bohemian specimens are pyritised, so that they cannot be permanently preserved. Dr. Anton Fritsch has devised the ingenious plan of making electrotypes from the moulds in the shale from which the decayed bones have been removed, and the exact copies of these fossils now exhibited are the result of his work.

Sub-order 3.—**Aistopoda.**

Wall-case 19. These closely resemble the Microsauria, with which they are found, but they are shaped like snakes and destitute of limbs. Remains of *Dolichosoma* and *Ophiderpetum* are exhibited.

Sub-order 4.—**Branchiosauria.**

Table-case U. The Branchiosauria ("gilled lizards") are so named because traces of the gill-supports are always conspicuous in young individuals. They are small animals like salamanders, with barrel-shaped vertebræ and short ribs. They are known only from the Lower Permian of France, Saxony, Bohemia, and Moravia. Numerous specimens of *Branchiosaurus* are exhibited from Saxony; and there is one individual from Bohemia showing an impression of the long soft tail on the black shale in which the skeleton is imbedded. The small *Protriton* from France and the relatively large *Melanerpetum* from Moravia are also represented by typical examples.

GALLERY No. 11.—FOSSIL FOOTPRINTS.

Gallery 11, Wall-cases 8–10.

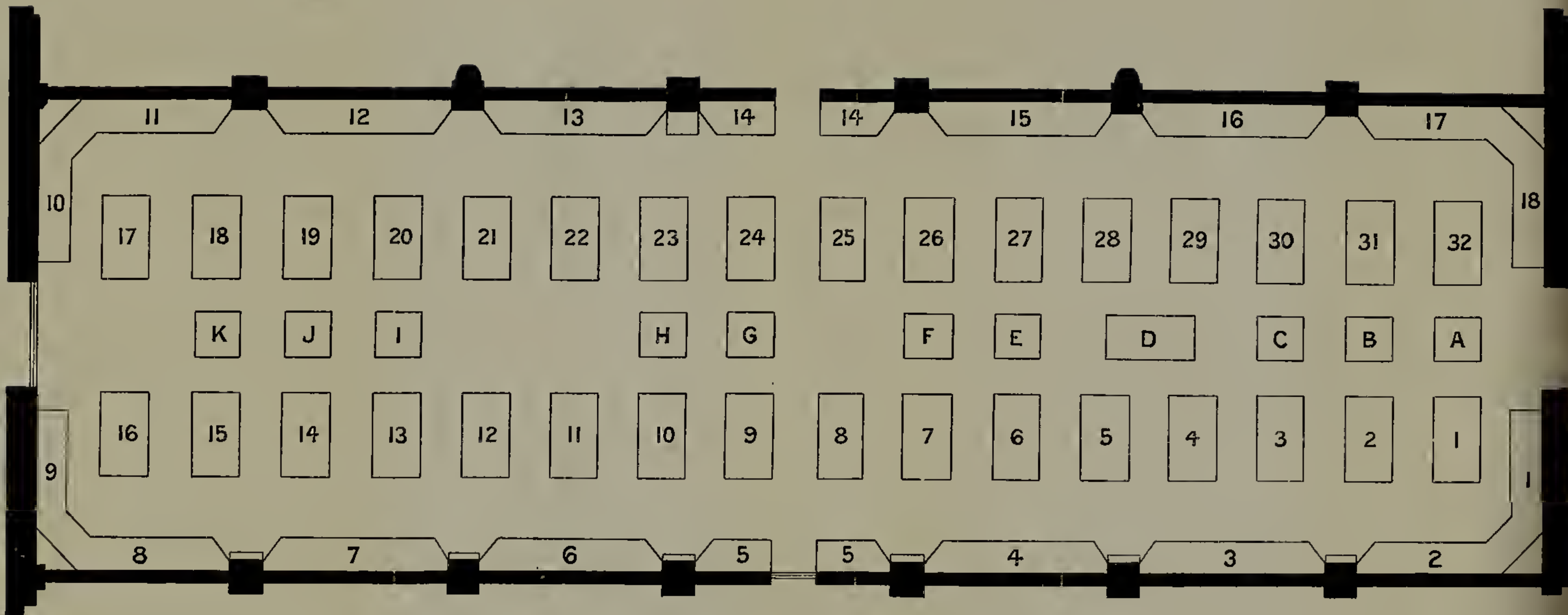
Under certain circumstances footprints may be preserved as fossils, and in some rocks of Triassic and Permian age the only evidence of life is afforded by such footprints. There is

Fig. 46.—Footprints of *Cheirotherium barthi*, with sun-cracks, from the Bunter Sandstone of Hessberg, Saxony; about one-tenth nat. size. (Wall-case 10, Gallery 11.)

a large series of these fossils in the collection, and as they cannot yet be ascribed to the animals which made them, they are arranged together in Gallery 11, Wall-cases 8–10. Most of the footprints from the English and German Trias (Fig. 46)

Gallery 11, Wall-cases 8–10.

are shaped somewhat like impressions of a human hand, and hence are referred to an unidentified *Cheirotherium* ("hand-beast"). There are small prints for the fore feet and large prints for the hind feet, and a close examination of the tracks shows that the "opposable thumb" is on the outer side of the foot, so really corresponds with the little finger or little toe of man. The so-called *Ichnium sphærodactylum* from the Permian of Thuringia is a nearly similar footprint, and is scattered over a large slab of red sandstone in Wall-case 10, which also exhibits suncracks and rainprints. Three-toed footprints from the Trias of North America (Wall-case 9) were probably made by Dinosaurs. Some large three-toed footprints of *Iguanodon* from the Wealden of Hastings are placed for comparison in Wall-case 8; and there is, on an adjoining stand, a slab of Purbeck Stone bearing similar impressions.



PLAN OF THE GALLERY OF FOSSIL FISHES.

CONTENTS OF WALL-CASES.

1, 2. Elasmobranchii. 3. Elasmobranchii and Holocephali. 4. Arthrodira. 5, 6. Crossopterygian Teleostomi. 7. Crossopterygian and Chondrostean Teleostomi. 8. Chondrostean Teleostomi. 9–13. Protospondylic Teleostomi. 14. Protospondylic and Aetheospondylic Teleostomi. 15. Isospondylic Teleostomi. 16. Isospondylic, Ostariophysian, and Acanthopterygian Teleostomi. 17, 18. Acanthopterygian Teleostomi.

CONTENTS OF TABLE-CASES.

A–D. Ostracodermi. E. Ostracodermi and Cycliae. F. Ichthyodorulites. G–K. Arthrodira. 1–8. Elasmobranchii. 9. Holocephali. 10. Dipnoi. 11, 12. Crossopterygian Teleostomi. 13–15. Chondrostean Teleostomi. 16. Chondrostean and Protospondylic Teleostomi. 17–20. Protospondylic Teleostomi. 21. Protospondylic and Aetheospondylic Teleostomi. 22–28. Isospondylic Teleostomi. 29. Ostariophysi and Apodes. 30. Anacanthini, Percesoces, Hemibranchii, Acanthopterygii. 31, 32. Acanthopterygii.

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GALLERY No. 6.—FOSSIL FISHES.

As fishes are aquatic animals and as most fossiliferous rocks have been formed in water, fish-remains are naturally very abundant among fossils. The geological record of their past history, however, is much more imperfect than might have been expected; for almost the only good specimens are those obtained from shoals which have been suddenly destroyed and quickly buried. Our real knowledge therefore depends on a succession of local accidents, which reveal only isolated episodes instead of a continuous story. Even these episodes are incompletely recorded, because the skeletons of a large proportion of the lower fishes are too little hardened with lime (or "calcified") to become fossilised when buried in rock.

Class V.—AGNATHA.

It is probable that all the earliest fish-like animals were destitute of hard parts capable of fossilisation, because no links have yet been found between fishes and the invertebrate animals below. When they first appear in Upper Silurian rocks their fossilised remains merely represent skin-armour, so that it is difficult to ascertain precisely the nature of their organisation. There is not much doubt, however, that the forerunners of the fishes lacked both a lower jaw as ordinarily fashioned and paired fins corresponding with the arms and legs of land animals. They are therefore arranged in a distinct Class of Agnatha ("without jaws") below that of Pisces (or fishes proper). These primitive animals occupy some of the small Cases in the middle of Gallery 6. **Table-cases A–E.**

Order I.—**OSTRACODERMI.**

Nearly all known Agnatha of the Silurian and Devonian periods are armoured with hard skin-tubercles, which are like the placoid scales of sharks, but often united into plates by

Table-cases A–E. an undergrowth of thin hard layers, bearing a superficial resemblance to ordinary shell. These are therefore named Ostracodermi ("shell-skinned") or Ostracophori ("shell-bearers").

SUB-ORDER 1.—**Anaspida.**

Table-case A. A few small Ostracoderms of Upper Silurian age are laterally compressed and gracefully fusiform, with one small dorsal fin and a heterocercal tail (see p. 61). The hard skin-tubercles on their head are not fused into plates, but those on the trunk have coalesced into well-formed scales, arranged in rows which slope from behind forwards instead of the reverse or ordinary way. *Birkenia* (Fig. 47) and *Lasanius* occur in the Downtonian formation of southern

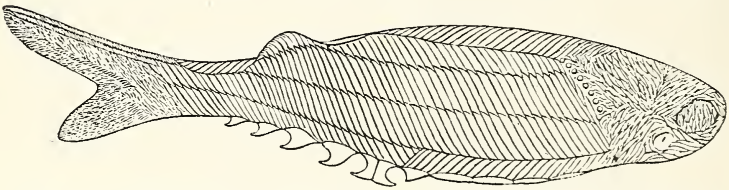

FIG. 47.—Restoration of *Birkenia elegans*, from the Downtonian of Lanarkshire; about nat. size. (After R. H. Traquair. Table-case A.)

Scotland, the former completely armoured, the latter showing only a few thick and deepened scales on the anterior part of the trunk besides a row of large recurved spines along the lower border. *Euphanerops* seems to have been a survivor of the Anaspida in the Upper Devonian of Canada.

SUB-ORDER 2.—**Heterostraci.**

Table-case A. In this group of Ostracoderms the head and gill-chamber region is relatively large, broad and depressed, so that it is exposed from above or below in the fossils; while the tail is slender and, seen in side view, ending in a forked tail-fin. The eyes are wide apart on the sides of the head. The mouth must have been underneath the head, and the opening from the gill-chamber on each side is at the hinder angle of the expanded front part of the animal. When the hard skin-tubercles are fused into plates, the underlying layers never contain true bone-cells.

The simplest of these Heterostraci ("anomalous-shelled")

are the Cœlolepidæ ("hollow scales"), which seem to have flourished earliest and must have been especially abundant in late Silurian seas. Their skin-tubercles were never united into plates, and when these little bodies were originally discovered in immense numbers in the Ludlow Bone-bed at the top of the Silurian formation on the borders of Shropshire (Table-case A) they were naturally mistaken for the placoid scales of sharks. It is only under exceptional circumstances that the animals covered with so incoherent an armour could be preserved intact, but good specimens have been found in the Upper Silurian and Downtonian shales of southern Scotland (Table-case A). In *Thelodus* the tubercles are quadrangular and flattened, while in *Lanarkia* (Fig. 48) **Table-case A.**

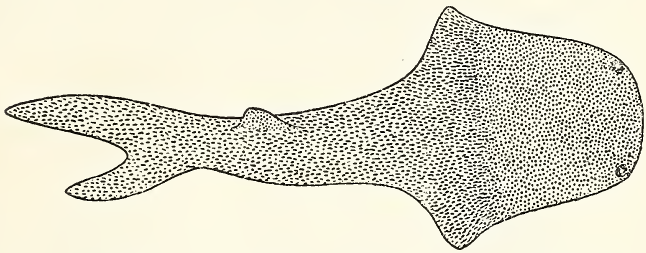

Fig. 48.—Restoration of *Thelodus scoticus*, from the Downtonian of Lanarkshire; about one-half nat. size. The head is shown from above, the tail twisted, to be seen mainly in side-view. (After R. H. Traquair. Table-case A.)

they are conical prickles of variable size. The internal skeleton is never preserved.

In the Pteraspidæ the skin-tubercles are united into plates and scales, and form fine enamelled ridges concentric with the edges. This family also flourished in the Upper Silurian, but is commoner and better developed in the Lower Devonian. *Cyathaspis* (Fig. 49) has been found in the Wenlock rocks of Gothland and in the Upper Silurian both of Europe and North America. It is the oldest fish-like organism of which there is any definite knowledge. *Pteraspis* (Figs. 50, 51) is a typical Lower Devonian genus, and numerous specimens are exhibited from the Lower Old Red Sandstone of the Welsh border. **Table-case A.**

The latest Heterostraci, which range from the Lower to the Upper Devonian, comprise some relatively large species, perhaps 2 feet in length, and form the family Psammosteidæ (Table-case B). The skin-tubercles fuse into small **Table-case B.**

Table-case A.

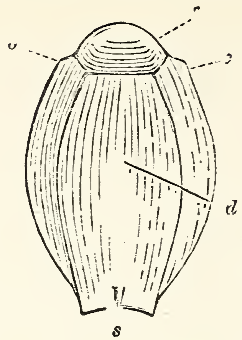

Fig. 49.—Diagram of dorsal shield of *Cyathaspis banksi*, upper view, from the Upper Silurian and Downtonian of Herefordshire; slightly reduced. *c*, cornua; *d*, median disc; *o*, position of orbit; *r*, rostral plate; *s*, posterior dorsal spine. (After Lankester. Table-case A.)

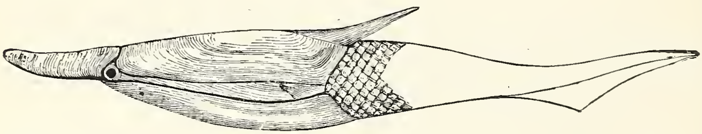

Fig. 50.—Restoration of *Pteraspis rostrata*, left side-view, from the Lower Old Red Sandstone of Herefordshire; about one-third nat. size. (After A. S. Woodward. Table-case A.)

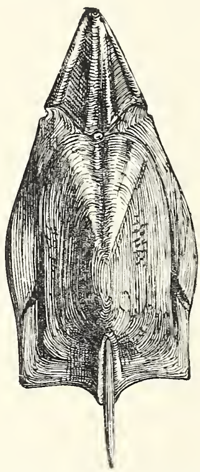

Fig. 51.—Dorsal shield of *Pteraspis rostrata*, upper view, from the Lower Old Red Sandstone of Herefordshire; about one-third nat. size. (After Lankester. Table-case A.)

polygonal plates, of which some are again united into large bilaterally symmetrical or paired shields. Good examples of *Drepanaspis* (Fig. 52) are exhibited from the Lower

Table-case B.

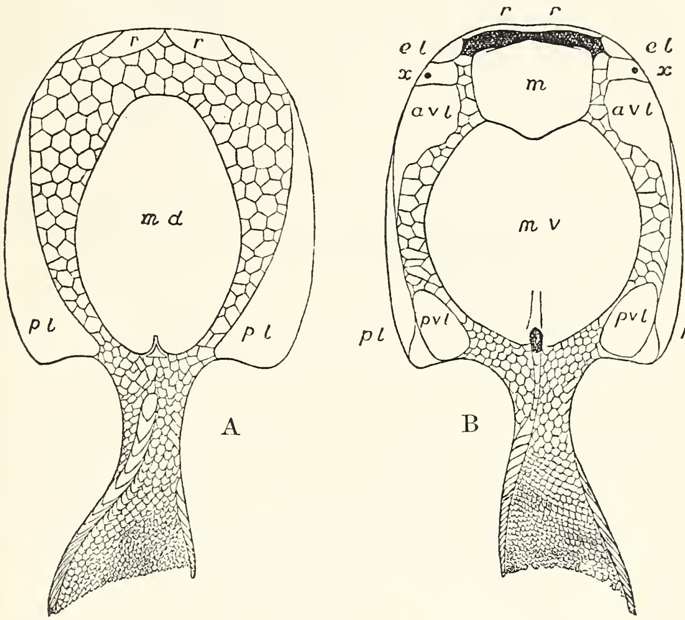

FIG. 52.—Restoration of *Drepanaspis gemuendenensis*, upper (A) and lower (B) view, from the Lower Devonian of Bundenbach, Germany; one-quarter nat. size. *a.v.l.* anterior ventro-lateral; *e.l.* external labial; *m.* mental, behind mouth; *m.d.* median dorsal; *m.v.* median ventral; *p.l.* postero-lateral; *p.v.l.* posterior ventro-lateral; *r.* rostral; *x.* orbital plate with orbit. (After R. H. Traquair. Table-case B.)

Devonian of Gmünden in Rhenish Prussia; and there are numerous fragments of *Psammosteus* from the Upper Devonian of Scotland, N.W. Russia, and Spitzbergen.

SUB-ORDER 3.—**Osteostraci.**

The Osteostraci ("bony-shelled") differ from the Heterostraci in the presence of bone-cells in some of the lower layers which unite the skin-tubercles into plates. They also differ in having the eyes close together on the top of the head. The Cephalaspidæ are the best-known family, ranging from the Upper Silurian to the Middle or even Upper Devonian, but

Table-cases B, C.

Table-cases B, C.

specially characteristic of the Lower Devonian both in Europe and North America. The unique collection of *Cephalaspis murchisoni* (Fig. 53) from the Lower Old Red Sandstone Passage Beds of Herefordshire, and fine specimens of other species from the Lower Old Red Sandstone of Scotland, exhibit nearly all the principal characters of the family (Table-cases B, C). At the back of the head region there is a pair of flippers, which seem to have assisted the expulsion

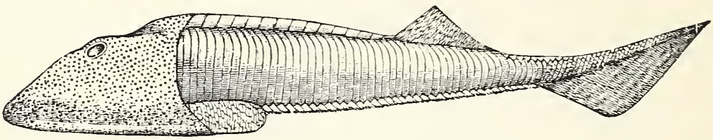

FIG. 53.—Restoration of *Cephalaspis murchisoni*, left side-view, from the Lower Old Red Sandstone Passage Beds of Herefordshire; about one-half nat. size. (After A. S. Woodward. Table-case B.)

of water from the gill-cavities. The scales on the sides of the trunk are deep and narrow. There is a small dorsal fin, and the tail is heterocercal (see p. 61). The Tremataspidæ comprise *Tremataspis* from the Upper Silurian of the Isle of Oesel (Baltic Sea) and *Didymaspis* from the Lower Old Red Sandstone Passage Beds (Downtonian) of Herefordshire.

SUB-ORDER 4.—**Antiarchi.**

Table-cases D, E.

These are the highest Ostracoderms, and are exclusively Devonian both in Europe and North America. The head and the anterior part of the trunk are covered with symmetrically-arranged overlapping plates, of which the lower layers contain bone-cells. The eyes are close together on the top of the head, which is movable on the trunk. A pair of toothed jaws of an unusual kind is fixed in front of the mouth. A pair of paddle-like appendages, each encased in plates and divided by one movable cross-joint, is articulated with the anterior angle of the body. The tail is heterocercal, and there is at least one small dorsal fin. The earliest known genus, *Pterichthys* (Fig. 54), is represented by an unique collection of specimens from the Middle Old Red Sandstone of Scotland in Table-case D; and with these there are two paper models made by the original discoverer, Hugh Miller. The tail of *Pterichthys* is scaly, but that of the Upper Devonian genera

Asterolepis and *Bothriolepis* seems to have been naked. Well- **Table-cases D, E.**

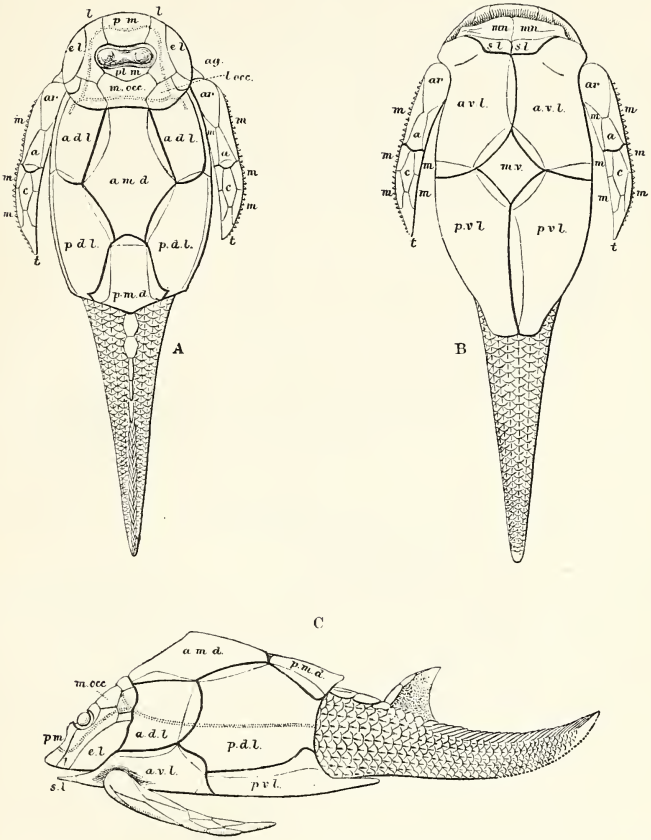

FIG. 54.—Restoration of *Pterichthys milleri*, upper (A), lower (B), and left side-view (C), from the Middle Old Red Sandstone of Scotland; about one-half nat. size. *a*, anconeal; *a.d.l.* anterior dorso-lateral; *a.m.d.* anterior median dorsal; *a.v.l.* anterior ventro-lateral; *ag.* angular; *ar.* articular; *c.* central of lower limb; *e.l.* extra-lateral or operculum; *l.* lateral; *l.occ.* lateral occipital; *m.* marginal; *m.occ.* median occipital; *m.v.* median ventral; *mn.* mandibular plates (displaced backwards in the drawing); *p.d.l.* posterior dorso-lateral; *pm.* premedian; *p.m.d.* posterior median dorsal; *p.v.l.* posterior ventro-lateral; *pt.m.* post-median; *s.l.* semi-lunar; *t.* terminal. (After R. H. Traquair. Table-case D.)

preserved examples of *Bothriolepis canadensis*, from the Province of Quebec, are especially noteworthy.

ORDER II.—CYCLIÆ.

Table-case E. The problematical small skeleton named *Palæospondylus gunni* (Fig. 55), from the Middle Old Red Sandstone of Caithness, seems to represent an otherwise unknown Order, which may perhaps be referred to the Agnatha. It is never more than about two inches in length, and the collection in Table-case E is thus supplemented by some enlarged wax-models of the fossil ingeniously made by the donor, Prof.

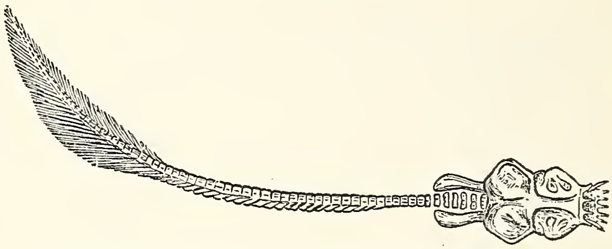

FIG. 55.—Restoration of *Palæospondylus gunni*, from the Middle Old Red Sandstone of Caithness; nearly twice nat. size. (After R. H. Traquair. Table-case E.)

W. J. Sollas. The head exhibits tentacle-shaped processes round an opening at the front end, and the roof of the brain-case is not sufficiently hardened for preservation. Bars which seem to be gill-arches occur below the back of the head, and they are connected in some way with a pair of plates extending behind the head. There are ring-vertebræ, and the tail is heterocercal, with hardened rays. There is no skin-armour.

Palæospondylus shows some striking resemblances to the lampreys, and it is quite possible that the existing Marsipobranchii are the degenerate survivors of the Agnatha.

CONODONTS.

Table-case E. Minute tooth-like bodies named Conodonts (Fig. 56) found detached in Palæozoic rocks from the Lower Silurian to the

FIG. 56.—Cambrian Conodonts, ten times nat. size. (After G. J. Hinde. Table-case E.)

Carboniferous Limestone inclusive, are sometimes compared with the teeth of lampreys and hag-fishes, but their exact nature is very doubtful. Specimens are exhibited from the Lower Carboniferous of Ohio, U.S.A. (Table-case E). **Table-case E.**

Class VI.—PISCES.

The earliest true fishes, with a well-formed lower jaw and paired fins, are represented by rare and fragmentary remains at the top of the Silurian rocks. Better-preserved specimens in the Lower Old Red Sandstone show them to have possessed only a cartilaginous internal skeleton, and no bone-cells in their external armour. They therefore probably belong almost to the same grade as the existing sharks (Elasmobranchii). The first fishes with a gill-cover and with bony tissue in their skeleton occur in the Middle Old Red Sandstone or Middle Devonian; and between these and

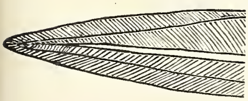

Fig. 57. — Protocercal or diphycercal tail; primitive type.

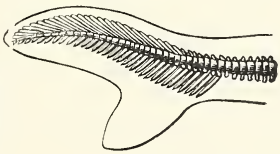

Fig. 58. — Heterocercal (unequal-lobed) tail: middle type.

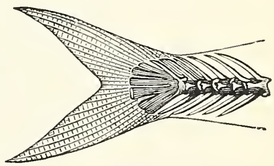

Fig. 59. — Homocercal (equal-lobed) tail; modern type.

modern fishes with a bony internal skeleton there are all gradations in successive geological formations. In the course of evolution it is interesting to observe that the tail undergoes considerable change. In all the older fishes the hinder extremity of the body tapers, and is either straight (Fig. 57) or with the fin almost or completely confined to the lower border (Fig. 58). In later fishes, the upturned end of the body in the unequal-lobed tail is more and more shortened, and the fin-rays gradually become so disposed that to all external appearance the tail assumes perfect symmetry (Fig. 59). Such changes are precisely repeated in the embryonic history of each existing bony fish; so that in the tail the history of the whole race corresponds with the history of each of its latest and highest individuals.

Classification of Fishes.

Sub-class I.—ELASMOBRANCHII. Jaw-apparatus suspended from skull; no operculum; dermal armour without bone-tissue ..	Elasmobranchii or Chondropterygii.
Order I.—Acanthodii. All fins except caudal with spine in front, and cartilages very short; no claspers in male	
Order II.—Pleuropterygii. Paired fins supported by parallel rods of cartilage; no claspers in male	
Order III.—Ichthyotomi. Pectoral fins supported by cartilages radiating from central axis; claspers in male	
Order IV.—Selachii. Pectoral fins with two or three basal cartilages and no central axis; claspers in male	
Sub-orders.—*Asterospondyli* and *Tectospondyli.*	
Sub-Class II.—HOLOCEPHALI. Jaw-apparatus fused with skull; an opercular membrane; dermal armour without bone-tissue ..	
Order I.—Chimæroidei. Fins as in Selachii	
Sub-class III.—DIPNOI. Jaw-apparatus fused with skull; an opercular bone; dermal armour often with bone-tissue	Dipnoi.
Order I.—Sirenoidei. Scaly fishes with paddle-shaped paired fins, these supported by a segmented axis	
Order II.—Arthrodira. Armoured fishes, the head-shield hinged on body-shield; paired fins rudimentary	Ganoidei.
Sub-Class IV.—TELEOSTOMI. Jaw-apparatus suspended from skull; an opercular bone; dermal armour often with bone-tissue ..	
Order I.—Crossopterygii. Paired fins paddle-shaped and fringed with fin-rays ..	
Sub-orders.—*Haplistia*, *Rhipidistia*, *Actinistia*, and *Cladistia*	
Order II.—Actinopterygii. Supports of paired fins much shortened and dermal rays chiefly supporting membrane .. .	
Sub-orders.—*Chondrostei*, *Protospondyli*, *Aetheospondyli*, *Isospondyli* (in part),	
Isospondyli (continued), *Ostariophysi*, *Apodes*, *Anacanthini*, *Percesoces*, *Hemibranchii*, and *Acanthopterygii*.	Teleostei.

The fossil true fishes are arranged in Gallery No. 6 in systematic order according to the above classification, the smaller specimens being in the Table-cases, the larger specimens in the Wall-cases. The series begins with the Elasmobranchii to the left of the door leading from Gallery No. 4.

Sub-class I.—Elasmobranchii.

Most of the fossil remains of sharks, dog-fishes, skates, and their extinct representatives, are very fragmentary, on account of the imperfect hardening of the internal skeleton by lime. In many cases only scattered teeth, spines, and hard skin-tubercles or "shagreen" remain. The detached fin-spines are rarely sufficient to indicate the nature of the fishes to which they originally belonged, and they are only referred to the Elasmobranchii because they have the same microscopic structure as the spines of modern sharks and skates. These fossils are named Ichthyodorulites (" fish-spine-stones "), and are arranged in the small Table-case F in the middle of the Gallery. Among them may be specially noticed the small ribbed spines of *Onchus* from the Lower Old Red Sandstone; *Oracanthus* from the Carboniferous Limestone; and *Listracanthus* from the Coal Measures. One of the largest known Ichthyodorulites is *Oracanthus pustulosus*, 26 inches in length, from the Carboniferous Limestone of Bristol, in Wall-case 2. **Table-case F.**

Order I.—ACANTHODII.

Wall-case 1. Table-case 1.

The oldest Elasmobranchs are the small Acanthodian fishes, ranging from the Upper Silurian to the Upper Permian. They are completely covered with regularly arranged shagreen, and they often exhibit a ring of plates

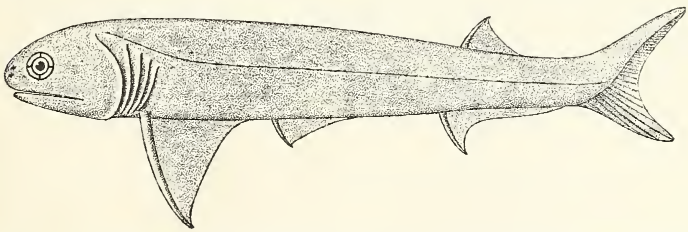

Fig. 60.—Restoration of *Acanthodes wardi*, from the Coal Measures of Staffordshire; about one-third nat. size. (Table-case 1.)

round the eye. When teeth are present these are firmly fixed to the edge of the jaws. The tail is heterocercal, and each of the other fins is armoured with a spine in front. The Upper Silurian and Lower Devonian Acanthodians

Wall-case 1. Table-case 1.

(*Climatius*, *Parexus*, etc.) have comparatively broad fin-spines obviously formed by the fusion of rows of hard tubercles; and there are pairs of these spines on the lower border of the fish between the pectoral and pelvic fins, as if the paired fins had originally been a pair of continuous membranes, afterwards sub-divided. The Middle and

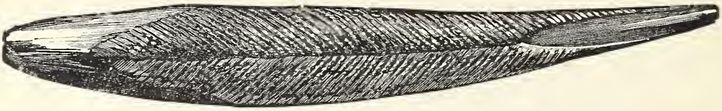

FIG. 61.—Fin-spine of *Gyracanthus formosus*, from the Coal Measures of Dalkeith; about one-third nat. size. (Table-case 1.)

Upper Devonian *Diplacanthus* and the Carboniferous and Permian *Acanthodes* (Fig. 60) are characterised by more slender fin-spines with little or no trace of intermediate paired spines. *Gyracanthus* is a curious Carboniferous genus, comprising comparatively large species, which are scarcely known except by their fin-spines (Fig. 61).

ORDER II.—PLEUROPTERYGII.

Wall-case 1. Table-case 2.

Wall-case 1 contains some fine specimens of an Upper Devonian shark, *Cladoselache*, representing another primitive group, in which the teeth are loosely arranged in the jaws as in modern sharks, while the paired fins are mere balancers supported by separate parallel rods of cartilage. As in Acanthodians, there is a ring of plates round the eye. The tail is heterocercal, though it is less conspicuous in the fossils than the horizontal keel of skin which extends along each side of its base. The nearly complete examples of *Cladoselache* have been discovered only in the Cleveland Shale of Ohio, U.S.A., the largest being 5 or 6 feet in length; but the teeth in this fish closely resemble those named *Cladodus*, which are commonly found isolated in the Lower Carboniferous both of America and Europe (Table-case 2), and probably belong to allied genera.

In some of the Palæozoic sharks the piercing or cutting teeth succeeded each other rapidly during life as in existing sharks, but did not fall from the outer edge of the mouth when they were no longer wanted. The used teeth of each transverse row united into an ever-increasing coil outside the

lip, until this phenomenon culminated in the strange spiral known as *Helicoprion* (Fig. 62) from the Permo-Carboniferous of Russia, Japan, and Australia (Table-case 2). **Table-case 2.**

FIG. 62.—Spiral row of teeth of *Helicoprion bessonowi*, from the Permo-Carboniferous of Perm, Russia; one-quarter nat. size. A. new teeth being formed; B. teeth in use; C. old teeth passed out of use. (After A. Karpinsky. Table-case 2.)

Edestus is a nearly similar cluster of teeth from the Carboniferous of North America and Europe. The sharks to which these teeth belonged may have been Pleuropterygii, but their relationships are still uncertain.

ORDER III.—ICHTHYOTOMI.

These are sharks with the paired fins paddle-shaped and supported by a more or less branched arrangement of cartilages like that in the paddles of Dipnoan fishes and Crossopterygii (p. 81). *Pleuracanthus* (Fig. 63) is the typical genus, represented in Table-case 2 by nearly complete fishes from the Lower Permian of Germany and Bohemia, and by spines and teeth (*Diplodus*) from various European and American Carboniferous and Lower Permian rocks. **Table-case 2.**

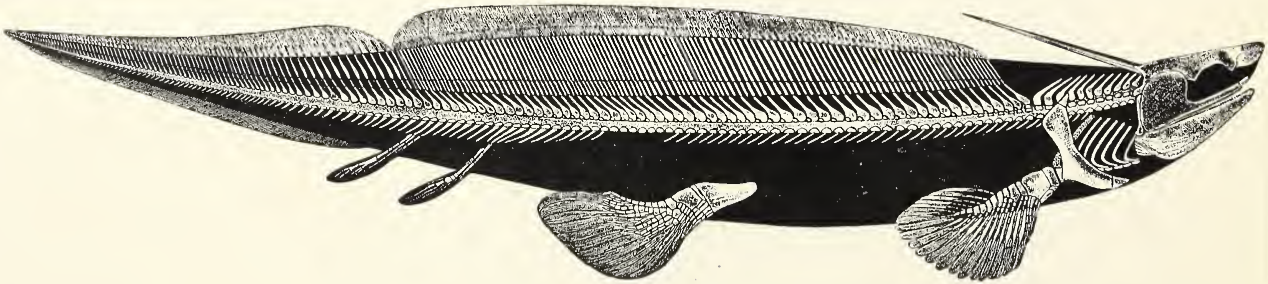

Fig. 63.—Restored skeleton of *Pleuracanthus decheni*, from the Lower Permian of Bohemia; about one-quarter nat. size. (After A. Fritsch, except that the paired fins have been reversed in direction. Table-case 2.)

Each tooth consists of a thick expanded base, bearing a divergent pair of conical cusps at its front edge, usually with an intermediate minute cusp. The slender spine is armed with a double longitudinal row of hook-shaped denticles, and is inserted on the back of the top of the head. The internal skeleton, which is sufficiently hardened with lime to be well preserved, shows that the notochord was not replaced by vertebral bodies. **Table-case 2.**

Order IV.—**SELACHII.**

These are the modern sharks and skates, in which the cartilaginous supports of the pectoral fins are fused at the upper end into three (occasionally two) basal pieces, with no branched arrangement, while the pelvic fins are borne on a well-developed pelvis. Vertebral bodies are well formed in most members of the Order. **Wall-cases 2, 3. Table-cases 3-8.**

The Palæozoic representatives of the Selachii are so imperfectly known that they cannot yet be satisfactorily classified. The Carboniferous teeth named *Psammodus* and *Copodus* (Table-case 3) are crushing plates suggestive of those of some of the largest existing skates. The Carboniferous and Permian Petalodontidæ (*Janassa*, *Petalodus*, etc.) are better known, but still of problematical relationships (Table-case 3). The Carboniferous Cochliodontidæ (Table-case 3) seem to have been allied to the existing Port Jackson shark (*Cestracion*), with dorsal fin-spines, and with crushing teeth which fused together into spirals (like *Helicoprion*, p. 65) instead of falling from the mouth when no longer in use. *Cochliodus* (Fig. 64) **Table-case 3.**

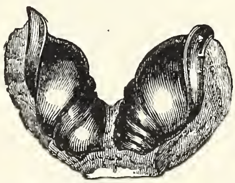

Fig. 64.—Jaw with teeth of *Cochliodus contortus*, from the Carboniferous Limestone of Armagh; one-half nat. size. (Table-case 3.)

is a typical example, and dental plates of this and allied sharks (*Psephodus*, *Pœcilodus*, *Helodus*, etc.) are not uncommon in the Carboniferous Limestone. Large portions of small fishes referable to *Helodus* are exhibited from the Staffordshire Coal Measures (John Ward Collection, Table-case 3).

Table-cases 4-8.

From the Lias onwards it is easy to distinguish the sharks and skates. The former, of the Sub-order **Asterospondyli** ("star-vertebræ"), always exhibit an anal fin, and when the vertebræ are strengthened, radiating plates predominate over concentric plates in their structure. The skates and their allies, of the Sub-order **Tectospondyli** ("covered vertebræ"), are destitute of an anal fin, and their vertebræ, when fully developed, are strengthened by hard concentric layers.

Sub-order 1.—**Asterospondyli.**

Table-case 6.

The Notidanidæ, which are perhaps the most primitive surviving family of sharks, are represented by numerous typical teeth of *Notidanus* from Upper Jurassic, Cretaceous, and Tertiary formations (Table-case 6). It is noteworthy that the largest and most complex teeth (Fig. 65) are those from the

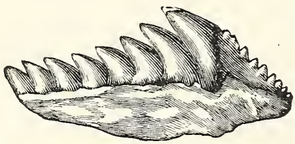

Fig. 65.—Tooth of *Notidanus gigas*, from the Red Crag of Suffolk; nat. size. (Table-case 6.)

Wall-cases 2, 3. Table-cases 4, 5.

latest deposits. The Cestraciontidæ are also primitive, and represented only at the present day by the Port Jackson shark, *Cestracion* (Figs. 66, 67), which lives on shell-fish, and has crushing teeth on the sides of the jaw with prehensile teeth in front. To this family may probably be referred the Carboniferous sharks, *Sphenacanthus* and *Tristychius*, which have cuspidate teeth and ribbed dorsal fin-spines (Wall-case 2, Table-case 4). The fine teeth of *Orodus* from the Carboniferous Limestone are also probably Cestraciont (Table-case 4). *Hybodus*, ranging from the Muschelkalk to the Wealden, exhibits a persistent notochord, cuspidate teeth, and ribbed dorsal fin-spines (Fig. 68); many specimens, presumably males, are further provided on each side of the head with two large barbed hooklets on a broad base (originally named *Sphenonchus*). The finest specimens of *Hybodus*, exhibited in Wall-case 2 and Table-case 4, were obtained from the Lower Lias of Lyme Regis, Dorset, and the Wealden of Pevensey Bay, Sussex. *Acrodus*, ranging from the Muschelkalk to the

Gault, only differs from *Hybodus* in its blunter teeth (Fig. 69). *Palæospinax*, from the Upper Lias of Würtemberg, is a small allied shark with smooth dorsal fin-spines and with simple vertebræ (Wall-case 3). *Synechodus* from the Chalk is nearly

Table-case 5.

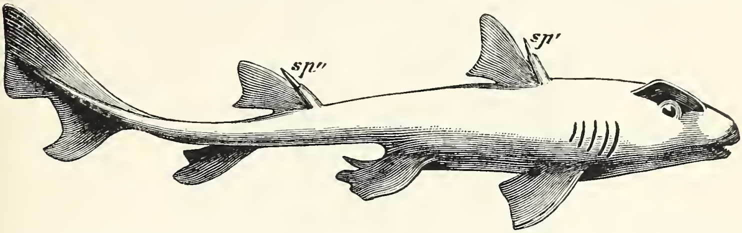

Fig. 66.—The existing Port Jackson Shark (*Cestracion philippi*), from Australian seas; much reduced. *sp'*. anterior dorsal fin-spine; *sp''*. posterior dorsal fin-spine.

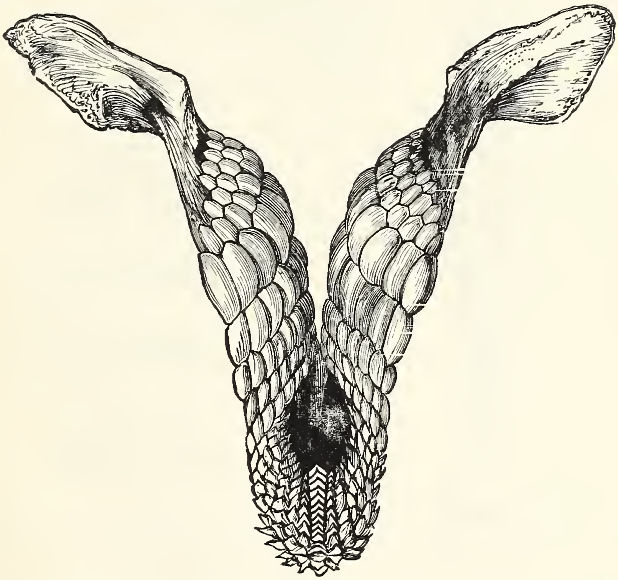

Fig. 67. Jaw of Port Jackson Shark (*Cestracion philippi*), showing grasping teeth in front, crushing teeth at the sides. (Table-case 5.)

similar (Table-case 5). *Asteracanthus*, with a dentition commonly named *Strophodus* (Fig. 70), agrees with *Hybodus* and *Acrodus* in most essential respects. As shown by good specimens from the Oxford Clay of Peterborough in Table-case 5, the head was armed with the so-called *Sphenonchus*.

Wall-case 3. Table-case 5.

Cestracion itself ranges from the Upper Jurassic onwards, and there is a well-preserved example in Wall-case 3 from the Upper Jurassic Lithographic Stone of Bavaria.

The Scylliidæ date from Upper Jurassic times, and there are well-preserved specimens of these small dog-fishes from

FIG. 68.—Dorsal fin-spine of *Hybodus*, from the Wealden of Sussex; about two-thirds nat. size. (Table-case 4.)

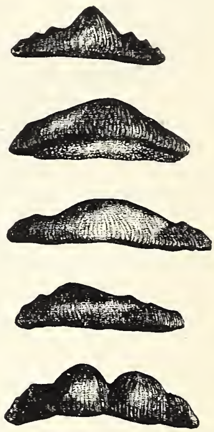

FIG. 69.—Teeth of *Acrodus anningiæ*, showing variation in shape, from the Lower Lias of Lyme Regis; nat. size. (Table-case 5.)

Wall-case 3. Table-case 6.

the Lithographic Stone of Bavaria and the Upper Cretaceous of Westphalia and Mount Lebanon in Wall-case 3 and Table-case 6. The Lamnidæ and Carchariidæ are the characteristic sharks of modern times, but are rarely found fossil except in the form of detached teeth, vertebræ, and pieces of cartilage. To the Lamnidæ may be assigned the fine examples of *Scapanorhynchus* from the Upper Cretaceous

of Mount Lebanon in Wall-case 3, this genus being almost identical with *Mitsukurina* now living off Japan. Numerous isolated teeth and groups of teeth of the same family from Cretaceous and Tertiary formations are exhibited in Table- **Wall-case 3. Table-cases 6, 7.**

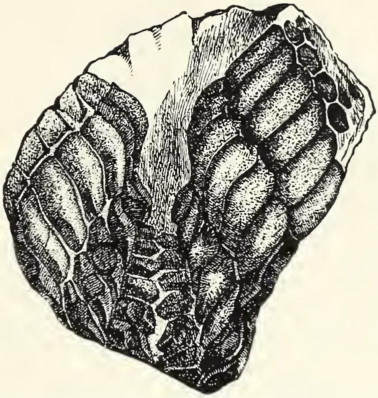

Fig. 70.—Jaw of *Asteracanthus* (*Strophodus medius*) from the Great Oolite of Caen, Normandy; one-third nat. size. (Table-case 5.)

cases 6, 7, but it is impossible to name them satisfactorily, owing to the variation of shape always occurring in one and the same mouth. The existing genera *Lamna, Oxyrhina, Odontaspis* (Fig. 71), and *Carcharodon* (Fig. 72), are repre-

Fig. 71.—Tooth of *Odontaspis elegans*, outer view, from the London Clay of Sheppey; nat. size. (Table-case 6.)

sented. The teeth of the largest extinct species, *Carcharodon megalodon*, have an almost world-wide distribution in Miocene and Pliocene formations; and some examples have been dredged in a semi-fossil state, impregnated with the oxides of iron and manganese, from great depths in the existing oceans (see the "Challenger" dredgings in a middle

Wall-case 3. Table-case 7.

Table-case in Gallery 10). The Carchariidæ are almost, if not exclusively, Tertiary, and only a small collection of the

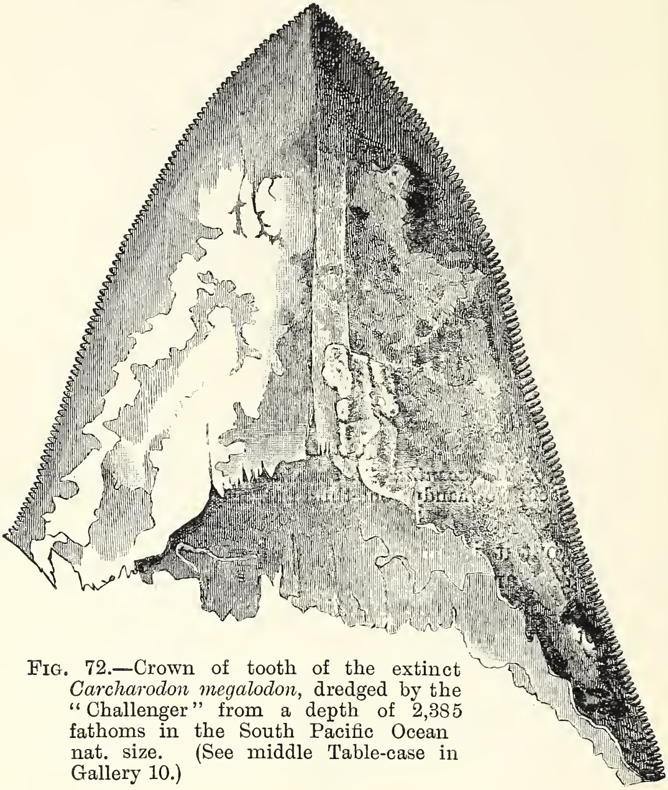

Fig. 72.—Crown of tooth of the extinct *Carcharodon megalodon*, dredged by the "Challenger" from a depth of 2,385 fathoms in the South Pacific Ocean nat. size. (See middle Table-case in Gallery 10.)

teeth and vertebræ of *Carcharias, Galeocerdo, Hemipristis*, etc., is exhibited (Table-case 7).

Sub-order 2.—**Tectospondyli.**

Wall-case 3. Table-cases 7, 8.

The surviving spiny dog-fishes or Spinacidæ seem most nearly to represent the ancestors of the skates, but they are only known to date back to the Cretaceous period. *Acanthias* and *Centrophorus* are represented by complete fishes in the Upper Cretaceous of Mount Lebanon (Table-case 7). The Pristiophoridæ and Pristidæ are proved to be of similar antiquity. *Sclerorhynchus* from Mount Lebanon is an

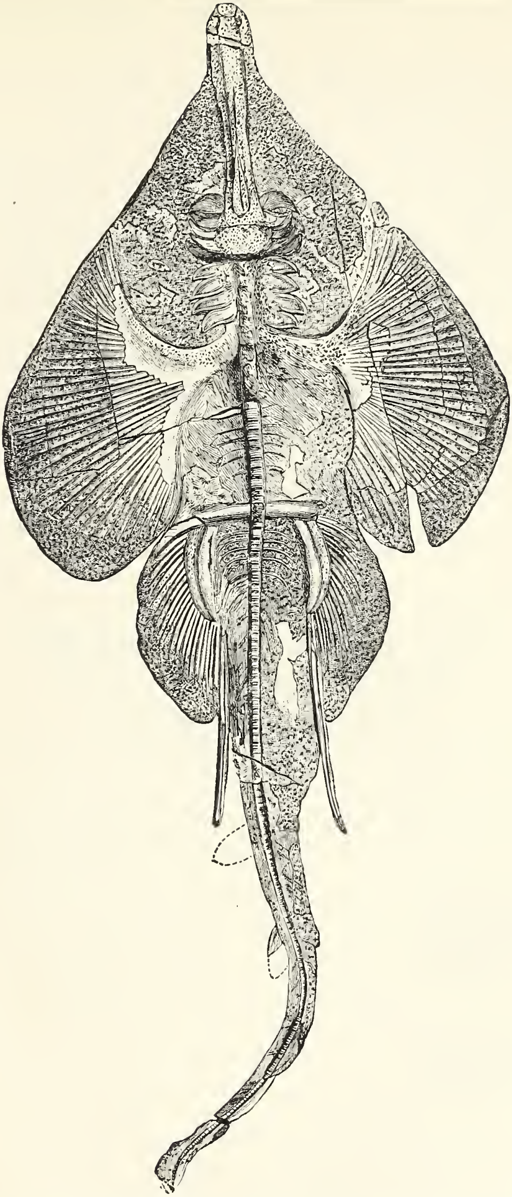

Fig. 73.—A fossil skate (*Rhinobatus bugesiacus*), male, from the Lithographic Stone of Eichstätt, Bavaria; about one-tenth nat. size. (A female specimen is mounted on the wall between Wall-cases 2, 3.)

Wall-case 3. Table-cases 7, 8.

ancestral saw-fish; while teeth and pieces of the saw of *Pristis* itself occur in Eocene deposits (Table-case 7). The

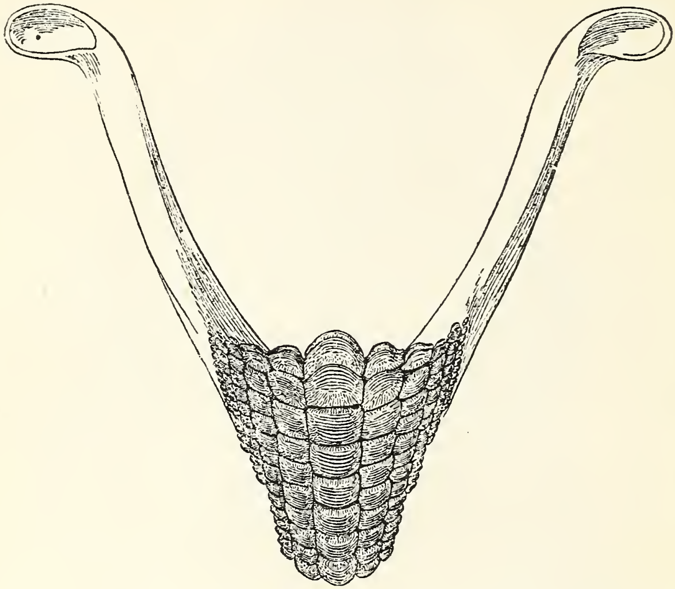

FIG. 74.—Mandible of *Ptychodus decurrens*, from the Lower Chalk of Sussex; reduced. (After A. S. Woodward. Table-case 8.)

Squatinidæ and Rhinobatidæ date back even to the Upper Jurassic; and well-preserved skeletons are exhibited both from the Bavarian and French Lithographic Stone, and from the Upper Cretaceous of Mount Lebanon (Wall-case 3, Table-case 7). The large skeletons of *Rhinobatus bugesiacus* (Fig. 73) and *Squatina acanthoderma*, mounted between Wall-cases 2, 3 and 3, 4, are especially noteworthy as beautifully preserved fossil fishes. Some of the Rajidæ and Trygonidæ are Upper Cretaceous, and the remarkable skeletons of *Cyclobatis* from Mount Lebanon, in Table-

FIG. 75.—Skin-tubercle of the existing Thornback (*Raja clavata*), outer view and side-view, showing the prickle; about nat. size. (Fossil in Red Crag, Table-case 7.)

case 8, are unusually good specimens. The well-known teeth of *Ptychodus* (Fig. 74), from the Chalk, seem to belong to a skate intermediate between these families and the Myliobatidæ or "devil fishes." An extensive collection is exhibited in Table-case 8. Typical portions of the dentition of *Myliobatis* itself occur abundantly in the English Eocenes, but the largest known specimen (*M. pentoni*) is from the Eocene of the Mokattam Hills near Cairo, Egypt (Table-case 8); *Aetobatis* and *Rhinoptera* are also Eocene. Skin-tubercles of the existing *Raja* occur in the Pliocene Crag (Fig. 75). **Wall-case 3. Table-cases 7, 8.**

Sub-class II.—Holocephali.

The Chimæroids do not differ much from the Elasmobranchs, except in the fusion of the upper jaw-cartilage with the skull; but fossils have not hitherto revealed any fishes definitely intermediate between these two Sub-classes. **Wall-case 3. Table-case 9.**

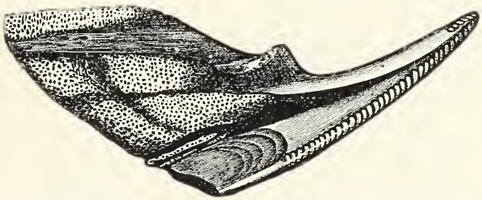

Fig. 76.—Left mandibular tooth of *Edaphodon leptognathus*, inner view, from the Middle Eocene of Bracklesham Bay, Sussex; about two-thirds nat. size. (Table-case 9.)

The teeth are large and reduced to not more than two pairs in the upper jaw and one pair in the lower jaw, while the whole dentition is shaped much like a beak.

Typical Chimæroid teeth, *Rhynchodus* and *Ptyctodus*, are found in the Devonian of North America and Europe; but some isolated teeth of this age are so peculiar that they may be either Chimæroid, Sirenoid (p. 76) or Arthrodiran (p. 79). The first satisfactory skeletons are those of the Jurassic period, and some are exhibited in Wall-case 3. The skeletons of *Squaloraja*, from the Lower Lias of Lyme Regis, are especially well preserved, and prove this fish to have been shaped like a narrow skate, with a long snout and a long tapering frontal spine in the male, but no dorsal fin-spine. *Myriacanthus*, from the same formation and locality, resembles

Wall-case 3. Table-case 9.

the existing *Callorhynchus* in the shape of its snout, but is peculiar in having a supplementary chisel-shaped tooth in front of the lower jaw. The still-surviving family of Chimæridæ is first represented by teeth of *Ganodus* and *Ischyodus* in the Lower Oolites (Table-case 9), the latter genus also ranging to the Upper Cretaceous. Good skeletons of *Ischyodus* are known from the Lithographic Stone of Bavaria, and part of one is exhibited in Wall-case 3. Some of the teeth of *Ischyodus* and of the Cretaceous and Eocene *Edaphodon* (Fig. 76) indicate species which must have been gigantic compared with any Chimæroid now living. *Chimæra* itself dates back at least to the Pliocene.

SUB-CLASS III.—DIPNOI.

Wall-case 5. Table-case 10.

The first ordinary fishes with a gill-cover and bony tissue in their skeletons are found in the Middle Old Red Sandstone. They have enamelled bony scales and external head-bones, but very little hardening of the internal cartilaginous skeleton. Their paired fins are paddle-shaped, with an internal skeleton of cartilage; and their tail is always diphycercal or heterocercal (see p. 61). Among these fishes one group is remarkable for the fusion of the upper jaw with the skull, as in Chimæroids and land vertebrates; and this peculiarity is combined with others suggesting that the group in question is connected in some way with the ancestors of the land vertebrates which must have been living in the Devonian period. The survivors of this group are provided not only with the ordinary gills but also with an air-bladder so modified that it can be used as a lung. The Sub-class they represent is therefore known as that of the Dipnoi ("double-breathers").

ORDER I.—**SIRENOIDEI.**

Wall-case 5. Table-case 10.

The living Dipnoi are confined to the widely-separated fresh-waters of South America (*Lepidosiren*), Africa (*Protopterus*), and Australia (*Ceratodus*). In past geological times the Order to which they belong was cosmopolitan. The earliest known genus is *Dipterus* (Figs. 77, 78, 1), of which good specimens from the Caithness flagstones are shown in Table-case 10. It is characterised by two dorsal fins (hence

its name), a heterocercal tail, and beautifully enamelled head-bones and scales. *Phaneropleuron*, with thin scales, occurs in the yellow Upper Old Red Sandstone of Dura Den, Fife- **Wall-case 5. Table-case 10.**

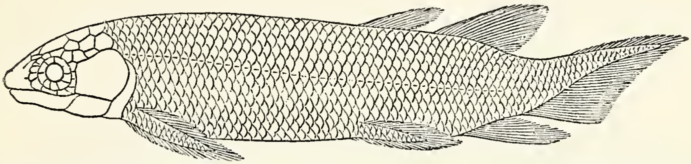

FIG. 77.—Restoration of *Dipterus valenciennesi*, from the Middle Old Red Sandstone of Scotland; one-fifth nat. size. (After R. H. Traquair. Table-case 10.)

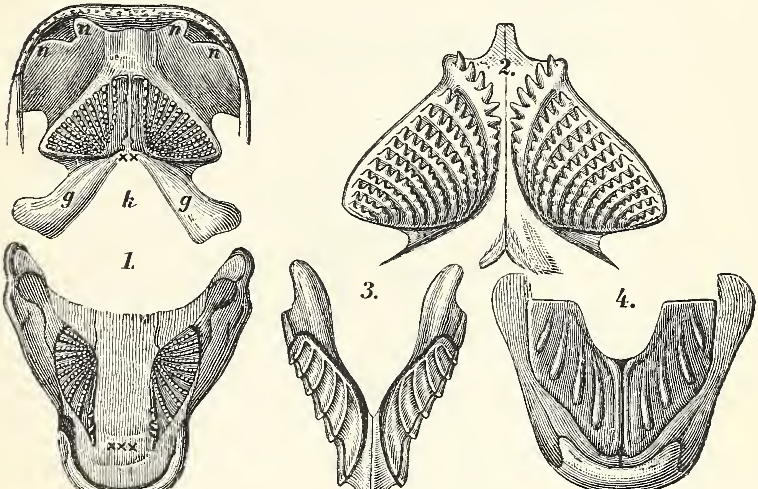

FIG. 78.—TEETH OF PALÆOZOIC DIPNOI. 1. Upper and lower jaws of *Dipterus valenciennesi*, from the Middle Old Red Sandstone of Scotland; nat. size. *xx*. upper teeth or dental plates; *xxx*. lower ditto; *g*. upper tooth-bearing bones; *n*. narial openings. 2. Lower teeth or dental plates of *Ctenodus cristatus* (bone wrongly drawn), from the Coal Measures; one-third nat. size. 3. Lower jaw of *Sagenodus inæqualis*, showing teeth, from the Coal Measures; one-half nat. size. 4. Part of lower jaw of *Palædaphus insignis*, with teeth, from the Upper Devonian of Belgium; one-sixth nat. size. (Table-case 10.)

shire (Wall-case 5), and *Scaumenacia* in the Upper Devonian of Canada (Table-case 10). *Ctenodus* (Fig. 78, 2) and *Sagenodus* (Fig. 78, 3) comprise large fishes known chiefly by fragments from the Carboniferous and Lower Permian of

Wall-case 5. Table-case 10.

Europe, North America, and Australia. All these early genera differ from the existing Dipnoi in having more numerous bones in the roof of their skull. Teeth identical with those of the existing Australian *Ceratodus* (Figs. 79, 80) are known from the Trias and Rhætic of Europe, India and South Africa; from the Jurassic of Europe, North America, and Australia; and from the Cretaceous of Pata-

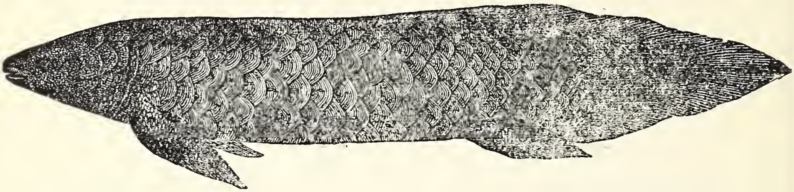

FIG. 79.—The existing Australian Mud-fish (*Ceratodus forsteri*), from rivers in Queensland; much reduced in size.

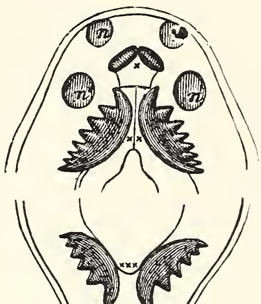

FIG. 80.—Mouth of *Ceratodus forsteri;* about one-half nat. size. *nn.* narial openings; *x.* vomerine teeth; *xx.* palato-pterygoid teeth; *xxx.* mandibular teeth.

gonia and Northern Africa. A skull which is more extensively ossified and otherwise slightly different from that of the existing *Ceratodus* was obtained by the Geological Survey of Austria from the Rhætic of that country. A typical collection of teeth from the Rhætic of Aust Cliff, near Bristol, and from the Trias of England, Würtemberg, India, and South Africa, is exhibited in Table-case 10.

ORDER II.—ARTHRODIRA.

During the Devonian period there flourished a race of armoured fishes, which exhibit some resemblance to the true Dipnoi in their teeth and appear to have agreed with the **Wall-case 4. Table-cases G–K.**

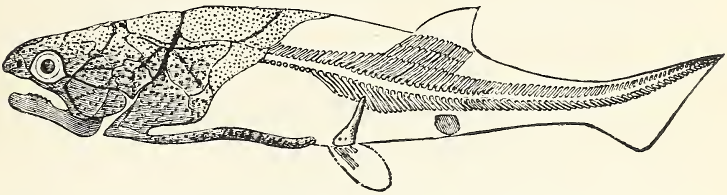

FIG. 81.—Restoration of *Coccosteus decipiens*, left side-view, from the Middle Old Red Sandstone of Scotland; about one-quarter nat. size. (After A. S. Woodward. Wall-case 4.)

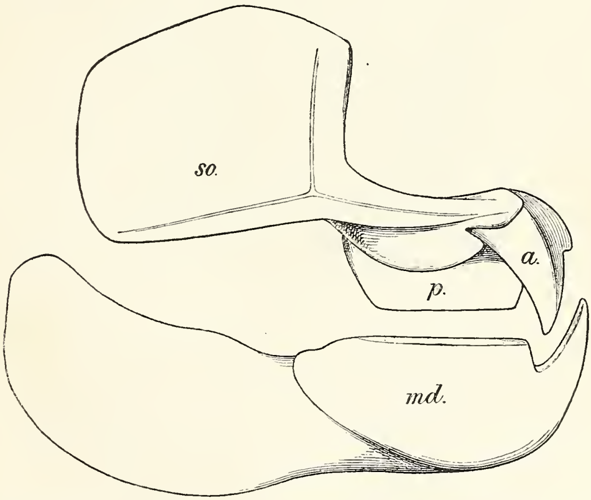

FIG. 82.—Jaws of *Dinichthys intermedius*, right side, outer view, from the Upper Devonian of Ohio; one-third nat. size. *a.* anterior upper piercing plate; *md.* mandible; *p.* posterior upper cutting plate; *so.* suborbital bone, showing groove for slime-canal. (Wall-case 4.)

latter in the fusion of the upper jaw with the skull. The armour of their head is movably articulated with that of the trunk by means of a pair of well-formed ball-and-socket joints, and hence they are named Arthrodira ("joint-necked").

Wall-case 4. Table-cases G–K.

Their remains occupy Wall-case 4, and the characteristically jointed neck is especially well seen in two mounted skulls of *Dinichthys*.

Coccosteus (Fig. 81), which attains a maximum length of about two feet, is the best known Arthrodiran, and is represented by a fine series of specimens from the Middle Old Red Sandstone of Scotland. All the armour-plates are

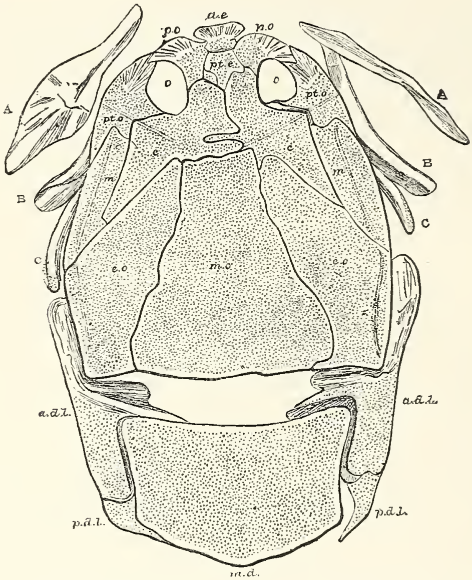

FIG. 83.—Upper view of armour of *Homosteus milleri*, from the Middle Old Red Sandstone of Caithness; one-sixth nat. size. A. B. C. undetermined bones; *a.d.l.* anterior dorso-lateral; *a.e.* ethmoid; *c.* central; *e.o.* external occipital; *m.* marginal; *m.d.* median dorsal; *m.o.* median occipital; *o.* orbit; *p.d.l.* posterior dorso-lateral; *p.o.* pre-orbital; *pt.e.* pineal; *pt.o.* post-orbital. The double lines indicate the course of the slime-canals. (After R. H. Traquair. Wall between Wall-cases 4, 5.)

deeply overlapping, but those of the trunk are confined to its front part just behind the head. The slightly hardened spines above and below the space which would originally be occupied by the notochord, as also the supports of the membranous dorsal fin, are seen in the naked trunk. There are plates which might have supported pectoral fins if such were present; and there are distinct remnants of a pair of posterior or pelvic fins. *Dinichthys* and its allies are large

and even gigantic *Coccosteus*-like fishes from the Upper Devonian of North America. The head sometimes measures 3 or 4 feet across, and one fragment of head-bone exhibited is nearly 4 inches in thickness. The teeth (Fig. 82) form powerful shears and pincers. The large collection of remains of *Dinichthys, Gorgonichthys, Titanichthys,* and allied genera in Wall-case 4 and Table-cases G to K was obtained by Dr. William Clark from the Cleveland Shale of Ohio. **Wall-case 4.**

Homosteus (Hugh Miller's "Asterolepis of Stromness") is another Arthrodiran of moderate size with thin armour, from the Middle Old Red Sandstone of Caithness, Orkney, and Russia, and is represented by plaster casts of fine specimens between Wall-cases 4, 5 (Fig. 83). *Heterosteus* is a gigantic allied fish, of which massive fragments from Russia are shown in Wall-case 4.

Phlyctænaspis is the earliest and smallest Arthrodiran, from the Lower Devonian of England, Galicia, and Canada (Table-case G).

Sub-class IV.—Teleostomi.

These are fishes with a bony armour or bony skeleton, or both; with a bony operculum covering the gill-cavity; and with the more or less hardened cartilages of the upper jaw not fused with the skull, but suspended from it behind. They are named Teleostomi ("complete mouth") because external or membrane bones form a complete border to the jaws. They comprise the immense majority of known fishes.

Order I.—**CROSSOPTERYGII.**

Most of the early paddle-finned fishes already mentioned on p. 76 have their upper jaw suspended as just described, and may thus be regarded as the direct forerunners of the bony fishes proper. They are named Crossopterygii ("fringe-finned") because their paddles are fringed with delicate filaments or fin-rays in the bordering skin. **Wall-cases 5–7. Table-cases 11, 12.**

The fringe-finned ganoids are now almost extinct, being represented only in the freshwaters of Africa by *Polypterus* and *Calamoichthys.* In the Devonian and Carboniferous periods they existed in large numbers and great variety, and were distributed nearly all over the world. *Holoptychius* (Fig. 84) is a well-known Devonian genus represented in the

Wall-cases 5–7. Table-cases 11, 12.

collection by fine specimens from the Old Red Sandstone of Scotland (Wall-case 5), and by more fragmentary remains from England, Russia, North America, and Greenland (Table-case 11). Its pectoral fins are as acutely lobate as in

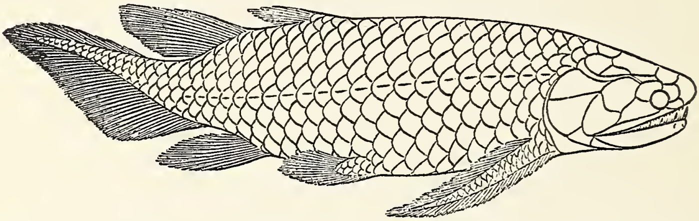

Fig. 84.—Restoration of *Holoptychius flemingi*, from the Upper Old Red Sandstone of Dura Den, Fifeshire; one-eighth nat. size. (After R. H. Traquair. Wall-case 5.)

Ceratodus, and its large overlapping scales are rounded, with a wrinkled ornamentation. Its teeth, as shown in transverse section (Fig. 85), are of a very complex structure, much resembling that observable in the teeth of Labyrinthodonts

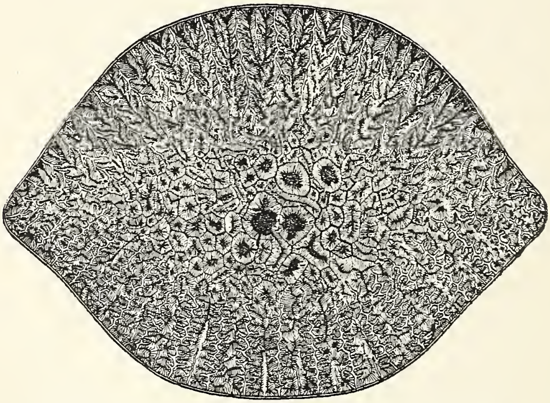

Fig. 85.—Transverse section of tooth of *Holoptychius*, showing complicated "dendrodont" structure; much enlarged. (After C. H. Pander.)

(p. 47). This fish lived in shoals which were sometimes suddenly destroyed and buried, as shown by a remarkable slab of Old Red Sandstone from Dura Den, Fifeshire, framed between Wall-cases 5, 6. *Osteolepis* (Fig. 86), *Diplopterus*,

Thursius, and *Glyptolœmus* are Devonian Crossopterygians with obtusely lobate pectoral fins, rhombic scales, and teeth of simpler structure (Wall-case 6, Table-case 11). *Megalichthys*, also with rhombic enamelled scales, comprises some relatively large species of Carboniferous and Lower Permian age, and its remains are among the commonest fossils of the **Wall-cases 5–7. Table-cases 11, 12.**

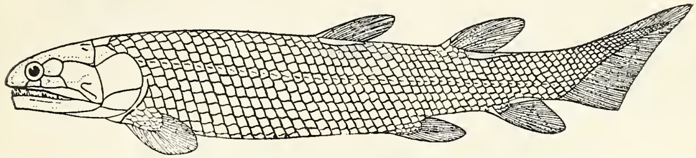

Fig. 86.—Restoration of *Osteolepis macrolepidotus*, from the Middle Old Red Sandstone of Scotland; one-third nat. size. (After R. H. Traquair. Wall-case 6.)

English Coal Measures (Wall-case 6, Table-case 11). *Rhizodus* is a still larger fish with deeply-overlapping round scales, from the Lower Carboniferous. Some of the large teeth and jaws of *Rhizodus hibberti* from the Lower Carboniferous of Scotland in Wall-case 6 probably belong to fishes 9 or 10 feet in length. *Strepsodus* (Fig. 87) and *Rhizodopsis* are allied genera, whose teeth and scales are common coal fossils.

The Cœlacanthidæ ("hollow-spined") are the most remarkable Crossopterygians, ranging almost unchanged from the Upper Devonian to the Upper Chalk (Wall-case 7; Table-case 12). Their name refers to the circumstance that the spines of the backbone are only superficially ossified and so appear hollow when fossilised. Their general appearance is shown by the accompanying drawing of *Undina* (Fig. 88), which is represented in Table-case 12 by fine specimens from the Upper Jurassic Lithographic Stone of Bavaria, and from the Lower Lias of England. The large air-bladder seen beneath the backbone in many specimens, especially in those from the Chalk, has a thin bony wall, as in some existing fresh- **Wall-case 7. Table-case 12.**

Fig. 87.—Tooth of *Strepsodus sauroides*, from the English Coal Measures; nat. size. (Table-case 11.)

G 2

Wall-case 7. Table-case 12.

water teleosteans. *Cœlacanthus* is Carboniferous and Permian; *Undina* is always Jurassic; *Macropoma* is Cretaceous,

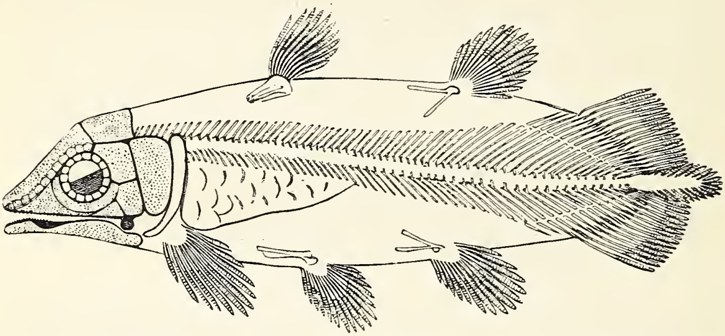

Fig. 88.—Restoration of *Undina* (*Holophagus*) *gulo*, from the Lower Lias of Lyme Regis; about one-seventh nat. size. (After A. S. Woodward. Wall-case 7 and Table-case 12.)

and is represented in Wall-case 7 by the unique collection of Dr. Gideon Mantell, besides later acquisitions from the English Chalk.

Order II.—**ACTINOPTERYGII.**

Paddle-like fins may be effective for a sluggish life in shallow waters and marshes, but they are less well adapted for active swimming away from the shore. Progress in the direction of modern fishes therefore only became rapid when the fins lost their basal lobe and became light flexible flaps of membrane stiffened merely by delicate filaments or fin-rays. Thus arose the highest grade of fish-life, known as that of the Actinopterygii ("ray-finned").

Sub-order 1.—**Chondrostei.**

Wall-cases 7, 8. Table-cases 13–16.

The earliest Actinopterygians still resembled the Crossopterygians of the same period in the excessive hardening of the external skeleton, in the heterocercal condition of the tail, and in the circumstance that the rays of the median fins were more numerous than the pieces of cartilage fixed in the flesh to support them. So long as fishes retained this combination of characters their internal skeleton never progressed, and they eventually terminated in the existing

degenerate sturgeons (Fig. 94). Such fishes are appropriately named Chondrostei ("gristle-boned").

The earliest Chondrosteans are the Palæoniscidæ, which are rapacious fishes with complete jaws, well-formed external head-bones, and usually a regular covering of enamelled rhombic scales, united by peg-and-socket joints (Fig. 89). *Cheirolepis* is their oldest known representative, from the Middle Old Red Sandstone of Scotland and the Upper Devonian of Canada (Wall-case 8), but they are specially characteristic of Carboniferous and Permian formations. *Palæoniscus* itself (Fig. 90) is Upper Permian (Table-case 14). *Elonichthys, Rhadinichthys,* and *Gonatodus* are the commonest Carboniferous genera; *Acrolepis, Amblypterus,* and *Pygopterus* occur with *Palæoniscus* in the Permian; *Gyrolepis* is Triassic, and *Atherstonia* is abundant in the Karoo Formation of South Africa (Table-case 15); *Oxygnathus* and *Platysiagum* are Liassic (Wall-case 8); and *Coccolepis* ranges from the Lias to the Purbeck Beds (Table-case 15).

Wall-case 8. Table-cases 13–15.

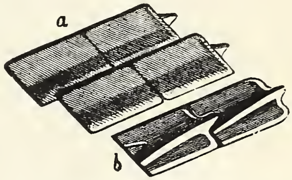

Fig. 89.—Ganoid scales of *Elonichthys striatus*, outer view (*a*) and inner face (*b*), from the Lower Carboniferous of Scotland; nat. size. The inner face shows the peg-and-socket articulation.

The Platysomidæ are deep-bodied fishes with stumpy

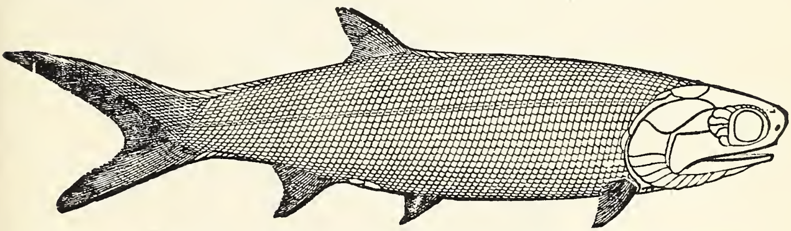

Fig. 90.—Restoration of *Palæoniscus macropomus*, from the Upper Permian of Germany; nearly one-half nat. size. (After R. H. Traquair. Table-case 14.)

teeth, closely related to the Palæoniscidæ, but confined to Carboniferous and Permian rocks. *Eurynotus* (Fig. 91) is Lower Carboniferous, while *Platysomus* (Fig. 92) is both Carboniferous and Permian.

Wall-case 8. Table-cases 15, 16.

The Catopteridæ are small Triassic Chondrosteans in which

Wall-case 8. Table-case 16.

the upper lobe of the tail is much shortened and the rays of the dorsal and anal fins are nearly as few as their supporting cartilages. They are therefore intermediate between the

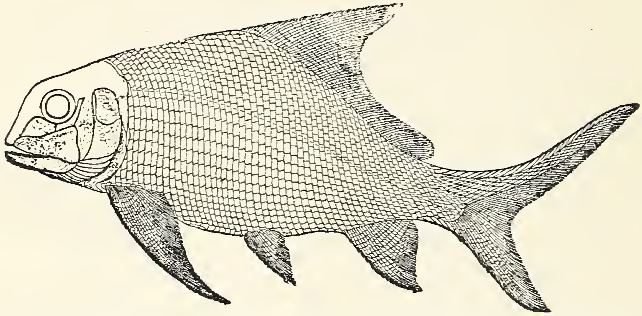

Fig. 91.—Restoration of *Eurynotus crenatus*, from the Lower Carboniferous of Scotland; about one-quarter nat. size. (After R. H. Traquair. Table-case 15.)

Chondrostei and the next higher sub-order of fishes. They are represented by *Catopterus* from North America, and by *Dictyopyge* from Europe, North America, and Australia.

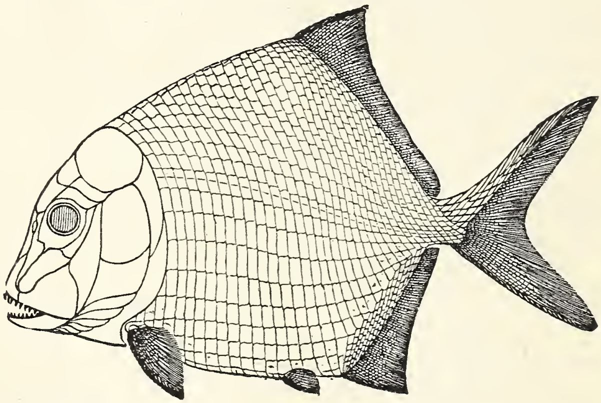

Fig. 92.—Restoration of *Platysomus striatus*, from the Upper Permian of Germany and N. England; about one-quarter nat. size. (After R. H. Traquair. Table-case 15 and Wall-case 8.)

Table-case 16.

The Triassic and Liassic Belonorhynchidæ seem to be elongated and degenerate Chondrosteans. As shown by *Belonorhynchus*, of which good specimens are exhibited in

Order—**Actinopterygii.** Sub-order—**Chondrostei.**

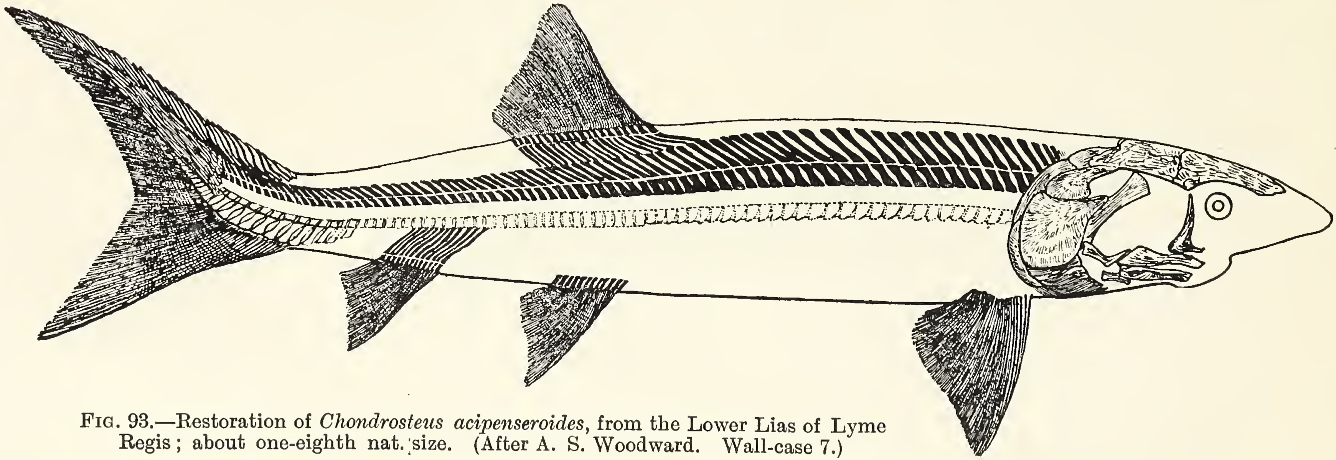

Fig. 93.—Restoration of *Chondrosteus acipenseroides*, from the Lower Lias of Lyme Regis; about one-eighth nat. size. (After A. S. Woodward. Wall-case 7.)

ORDER—**Actinopterygii.** SUB-ORDER—**Chondrostei.**

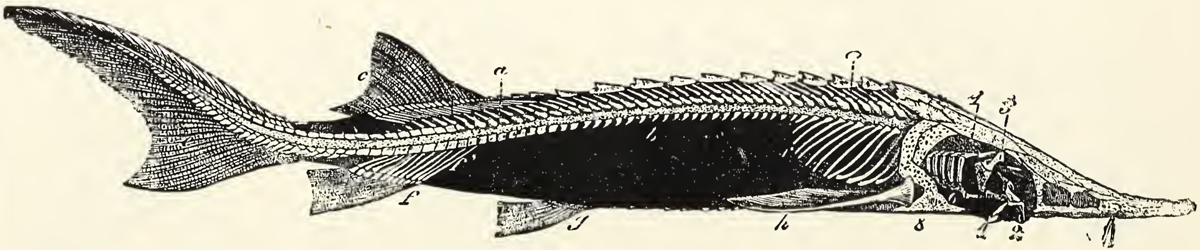

FIG. 94.—Skeleton of existing Sturgeon (*Acipenser*). 1. posterior extremity of cartilaginous cranium beneath the head plates; 2. upper jaw; 3. hyomandibular bone; 4. lower jaw; 6. gill-arches; 8. pectoral arch; *a.* neural arches and spines, placed above the notochord; *b.* hæmal arches, placed below the notochord; *c.* dorsal fin; *e.* caudal fin; *f.* anal fin; *g.* pair of pelvic fins; *h.* pair of pectoral fins; *r.* ribs.

Table-case 16, their snout is long and pointed, their tail is diphycercal (see p. 61), and their trunk is armoured with only four longitudinal rows of bony plates or scutes. The common Rhætic teeth named *Saurichthys* seem to belong to fishes of this family. **Table-case 16.**

The Chondrosteidæ, represented by *Chondrosteus* (Fig. 93) from the Lower Lias of Lyme Regis, perhaps also by the gigantic *Gyrosteus* from the Upper Lias of Whitby, are intermediate between the Palæoniscidæ and the modern sturgeons. The fine specimens exhibited show that the internal skeleton is identical with that of the sturgeons (Fig. 94), and that the jaws are reduced and toothless; but the roof of the skull and the development of the rays below the gill-cover more closely resemble the corresponding parts in Palæoniscids. **Wall-case 7.**

A few dermal scutes identical with those of the existing sturgeon, *Acipenser*, are shown from the English Eocene. There are also pectoral fin-spines from both the Eocene and the Pliocene (Table-case 16).

Sub-order 2.—**Protospondyli.**

So soon as the rays of the dorsal and anal fins had become equal in number to their supports, and so soon as the upper lobe of the tail had been permanently reduced to an insignificant stump, fishes began to advance in the hardening or ossification of their internal head-bones and in the acquisition of a well-formed back-bone. Each vertebral body originally began as four separate pieces surrounding the notochord, the upper and lower pairs first uniting into crescents, and these two again fusing into a complete ring. The most characteristic fishes of the Triassic, Rhætic, Jurassic, and Lower Cretaceous periods were in this condition. They form the sub-order Protospondyli ("first vertebræ"), and their sole survivor at the present day is the "bow-fin" or *Amia* of North American lakes and rivers. They are represented in the collection by a very extensive series of fine specimens, those from the English Lias and Wealden and from the Bavarian Lithographic Stone being especially noteworthy. **Wall-cases 9-14. Table-cases 16–21.**

The first family is that of the Semionotidæ, already represented by one genus of small fishes, *Acentrophorus*, in the Upper Permian. They are stout-bodied, with a small mouth and blunt, often powerfully crushing, teeth. *Semionotus* and *Colobodus* are Triassic and Rhætic; *Dapedius* (Fig. 95) is **Wall-cases 9-11. Table-cases 16, 17.**

Wall-cases 9–11. Table-cases 16, 17.

Liassic; and *Lepidotus* (Fig. 96) ranges from the Rhætic to the Wealden. The powerful dentition of *Lepidotus*, originally named *Sphærodus*, is particularly noteworthy; the successional teeth when first formed in the jaw being directed away from

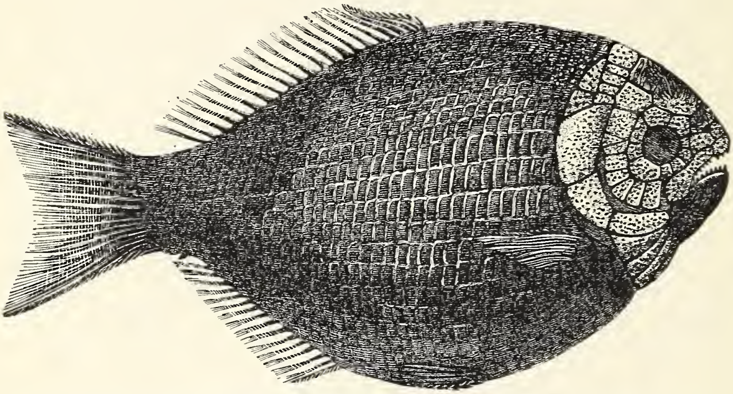

Fig. 95.—*Dapedius politus*, from the Lower Lias of Lyme Regis; one-quarter nat. size. (Wall-case 10.)

those they are destined to replace, and gradually turning through an angle of 180° as they come into use (see specimens in Table-case 16).

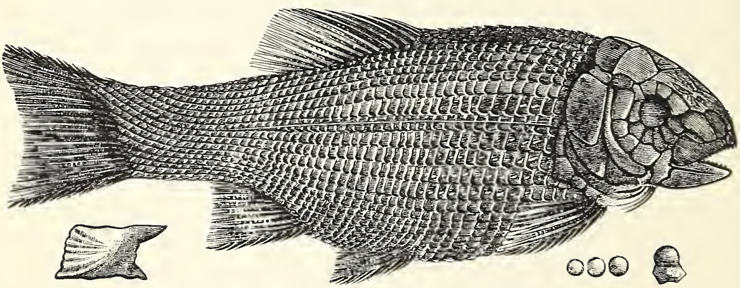

Fig. 96.—*Lepidotus mantelli*, from the Wealden of Sussex; one-tenth nat. size. A scale and some crushing teeth, less reduced, below. (Wall-case 9.)

Wall-case 11. Table-case 17.

The Macrosemiidæ are elongated fishes with small mouth, obtuse teeth, and extended dorsal fin, ranging from the Rhætic to the Chalk. Good examples of *Ophiopsis* and *Macrosemius* are shown from the Lithographic Stone of

Bavaria and France, others of *Ophiopsis* and *Histionotus* from the Purbeck Stone of Dorsetshire and Wiltshire.

The Pycnodontidæ ("thick-toothed") are a remarkable family of deep-bodied fishes, so-called in allusion to the powerful grinding teeth (Fig. 97) which arm their forwardly-displaced mouth. The rhombic scales are usually so thin that their ribbed front margin is often the only part preserved, producing the appearance of a series of parallel streaks from the upper to the lower margin of the trunk. In

Wall-case 11. Table-cases 18, 19.

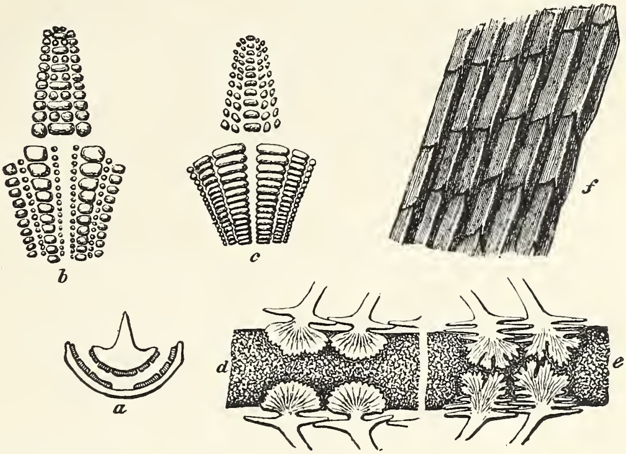

FIG. 97.—Parts of the skeleton of Pycnodont Fishes. *a.* transverse section of jaws, showing the two halves of the mandibular dentition opposing the vomerine teeth; *b.* vomerine and mandibular teeth of *Microdon*; *c.* vomerine and mandibular teeth of *Cœlodus*; *d.* portion of vertebral column of *Cœlodus*, showing persistent notochord (shaded) and the expanded bases of the arches; *e.* the same of *Pycnodus*; *f.* inner view of scales, showing mode of interlocking by pegs and sockets, which are continued as longitudinal ribs. (After J. J. Heckel.)

several genera (*e.g.*, *Mesodon*, *Microdon*, and *Cœlodus*) the tail is destitute of scales. These fishes range from the Lower Lias (*Mesodon liassicus*) to the Upper Eocene (*Pycnodus platessus*) with very little modification. The fine series of examples of *Gyrodus* from the Lithographic Stone of Bavaria, and of *Palæobalistum* from the Hard Chalk of Mount Lebanon, are particularly worthy of attention. The armoured *Coccodus* and *Xenopholis* from Mount Lebanon are also remarkable. None of these fishes have vertebræ, but in the later genera the arches above and below the notochord are often expanded to unite at the sides (Fig. 97, *e*).

Wall-cases 12, 13. Table-cases 19, 20.

The Eugnathidæ are the rhombic-scaled forerunners of the modern *Amia*, and range from the Upper Trias or Rhætic to the Chalk. They are predaceous fishes with a large mouth and conical teeth. Both the thick-scaled *Eugnathus* (Fig. 98) and the thin-scaled *Caturus* (Fig. 99) range

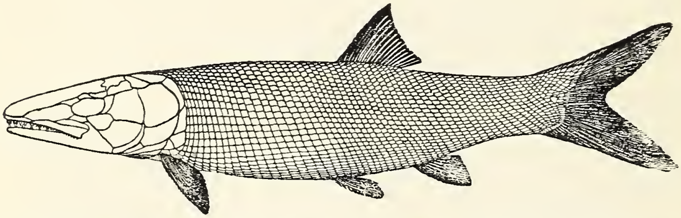

Fig. 98.—Restoration of *Eugnathus orthostomus*, from the Lower Lias of Lyme Regis: about one-seventh nat. size. (After A. S. Woodward. Wall-case 12.)

throughout the Jurassic; and there are allied fishes connecting these with the Amiidæ, which are first typically represented in the Upper Jurassic. *Megalurus* from the German and French Lithographic Stone only differs from *Amia* in its shorter dorsal fin. In the Lower Tertiaries *Amia* itself is as abundantly represented in Europe as in North America.

Table-case 20.

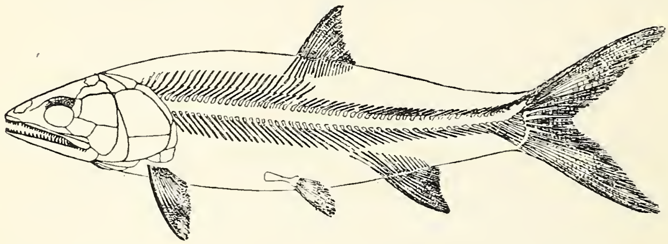

Fig. 99.—Restoration of *Caturus furcatus*, scales omitted, from the Upper Jurassic Lithographic Stone of Bavaria; about one-eleventh nat. size. (After A. S. Woodward. Wall-case 13.)

Good specimens are shown from the Lower Miocene of France, and there are fragments from the Hampshire Basin (Table-case 20).

Wall-case 13. Table-cases 20, 21.

The Pachycormidæ are a family of Amioids which curiously mimic the modern sword-fishes, and range throughout the Jurassic and Cretaceous periods. They are typically represented by *Pachycormus* (Upper Lias), *Hypsocormus* (Upper

Jurassic, Fig. 100), and *Protosphyræna* (Upper Cretaceous). The notochord is never much replaced by vertebral bodies, but to strengthen the trunk the vertebral arches are multiplied and very closely arranged; the powerful forked tail is supported by one fan-shaped lower vertebral arch; and the snout **Wall-case 13. Table-case 21.**

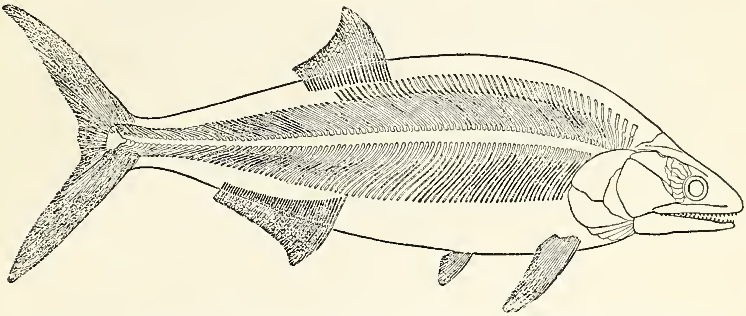

Fig. 100.—Restoration of *Hypsocormus insignis*, scales omitted, from the Upper Jurassic Lithographic Stone of Bavaria; about one-eighth nat. size. (After A. S. Woodward. Wall-case 13.)

gradually becomes elongated until it is a formidable weapon in *Protosphyræna*. The gigantic *Leedsia problematica*, from the Oxford Clay of Peterborough, seems to belong to this family. Its tail, mounted between Wall-cases 13–14, has a span of 9 feet, and probably represents a fish 30 feet in length.

Sub-order 3.—**Aetheospondyli.**

These fishes are ganoids resembling the Protospondyli except that their vertebral rings or bodies do not appear to **Wall-case 14. Table-case 21.**

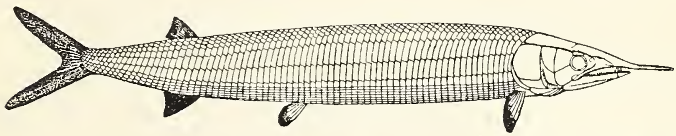

Fig. 101.—Restoration of *Aspidorhynchus acutirostris*, from the Upper Jurassic Lithographic Stone of Bavaria; about one-eleventh nat. size. (After A. S. Woodward. Wall-case 14.)

result from the fusion of once-separate crescentic pieces. *Aspidorhynchus* (Fig. 101), with constricted ring-vertebræ, is represented in Wall-case 14 by a fine series of specimens

Wall-case 14. Table-case 21. from the Lithographic Stone of Bavaria; while the closely related *Belonostomus* is both Upper Jurassic and Cretaceous (Table-case 21). Remains of species of the existing American genus *Lepidosteus*, or "bony pikes," are found in the Lower Tertiaries of Europe, and many of the characteristic concavo-convex vertebræ, with scales, are exhibited from the Upper Eocene of Hordwell, Hampshire.

All the preceding fishes have a complex lower jaw, each half consisting of at least four or five pieces; and when the teeth are powerful, those on the inner (or splenial) element are specially well-developed. In the following groups, on the other hand, the lower jaw consists normally of only two pieces on each side, one behind (articulo-angular) and a larger piece (dentary) in front.

Sub-order 4.—**Isospondyli.**

Wall-cases 15, 16. Table-cases 22–28. In the first and earliest group of the higher fishes the vertebræ never fuse into a complex behind the head, the simple air bladder is directly connected with the gullet, and the pelvic fins are always situated well behind the pectorals. Here may be placed the Pholidophoridæ, which are remarkably like the herrings in general aspect, but have ganoid scales, fulcra on all the fins, and only ring-vertebræ. *Pholidophorus* itself ranges from the Rhætic **Table-case 22.** to the Purbeck Beds, but is especially well represented by a large series of specimens from the Lower Lias of Lyme Regis. Some diminutive fishes of the genera *Peltopleurus* (Upper Trias) and *Pleuropholis* (Kimmeridgian and Purbeckian) exhibit a series of remarkably deepened scales **Wall-case 15. Table-cases 23, 24.** on the flank. The Oligopleuridæ, ranging from the Upper Jurassic to the Upper Cretaceous, come next. The Leptolepidæ follow, with *Leptolepis*, *Aethalion*, and *Thrissops*, mostly from the Lithographic Stone of Bavaria; and these differ from the herrings (Clupeidæ) chiefly in the meeting of the parietal bones and in the simple character of the tail. *Leptolepis* (Fig. 102) is first represented by small species in the Upper Lias of England, France and Würtemberg.

Either here or immediately after the "Amioids" (the Pholidophoridæ having previously been classed with the "Lepidosteoids"), it has long been customary to recognise a break in the series of Teleostomatous fishes. All groups below have been united under the name of Ganoidei (enamel-scaled fishes); all above have been termed Teleostei (bony

fishes). This arrangement was very convenient so long as the extinct families were more incompletely known; but fossils now show that it cannot be scientifically maintained, and the

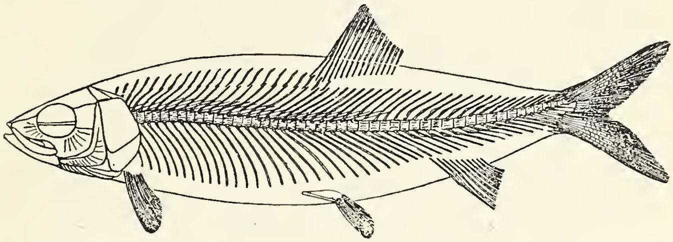

FIG. 102.—Restoration of *Leptolepis dubius*, scales omitted, from the Upper Jurassic Lithographic Stone of Bavaria; about one-third nat. size. (After A. S. Woodward. Table-case 23.)

terms "Ganoid" and "Teleostean" must accordingly be employed in future merely in a general way for enamel-scaled and modern bony fishes respectively.

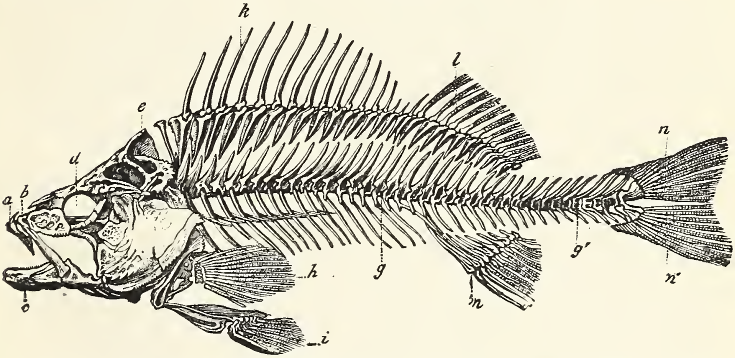

FIG. 103.—Skeleton of the Common Perch (*Perca fluviatilis*). *a.* premaxillary bone; *b.* maxillary bone; *c.* lower jaw; *d.* palatine arch; *e.* cranium; *f.* interoperculum; *g g′.* vertebral column; *h.* pectoral fin; *i.* pelvic fin; *k.* spinous dorsal fin; *l.* soft dorsal fin; *m.* anal fin; *n.* upper, and *n′.* lower lobe of caudal fin.

The pectoral and pelvic fins each form a pair, and correspond respectively with the anterior and posterior pairs of limbs of the higher vertebrata. The dorsal, caudal, and anal fins are median, unpaired, and peculiar to fishes.

Most of the so-called "Teleostean" fishes have a remarkably developed internal skeleton, as may be perceived from the accompanying figure of that of the common perch (Fig. 103). Very few are covered with bony scales, the large

majority being invested with thin and flexible deeply-overlapping scales, which are either smooth ("cycloid," Fig. 104, A) or pectinated ("ctenoid," Fig. 104, B) at the hinder margin.

FIG. 104.—Scales of Teleostean Fishes. (A) Cycloid; (B) Ctenoid. The right border is exposed in the fish, and the grooved left border is deeply overlapped by the next scales.

Wall-case 15. Table-case 25. Next to the Leptolepidæ in the collection are arranged the Elopidæ, which are the Cretaceous and Tertiary fishes perhaps most nearly related to the highest Jurassic families. Among these, in Table-case 25, the specimens of *Osmeroides* from the English Chalk are especially noteworthy, several having been beautifully worked out of the matrix by the late Dr. Mantell. Like many fossil fishes from the Chalk, they are almost uncompressed, the fine chalky mud having replaced the soft parts as rapidly as they decayed, thus preventing the collapse of the flanks and preserving almost the natural form of the living animal. *Thrissopater*, *Rhacolepis* and *Pachyrhizodus* are allied Cretaceous genera, while *Elops* and *Megalops* are Tertiary and still survive.

Wall-case 15. Table-case 25. Among the Albulidæ may be noticed well-preserved skeletons of *Istieus* from the Upper Cretaceous of Westphalia (Wall-case 15), which can scarcely be distinguished from the existing deep-sea fish, *Bathythrissa*. In fact, many of the Westphalian Cretaceous fishes are related to living deep-sea genera, the eel-shaped Halosauridæ (*Echidnocephalus*) in Table-case 27 being especially remarkable.

Wall-case 16. Table-case 26. The Chirocentridæ, which are proved by their sole survivor to be closely related to the "ganoids," are also well represented among Cretaceous fossils. The extinct forms are provided with powerful teeth implanted in distinct sockets on the margin of the jaw. *Portheus* attains a large size, as shown by a fine slab of *Portheus molossus* from the Kansas Chalk in Wall-case 16. More fragmentary remains of this genus, *Saurodon*, and *Ichthyodectes* are also exhibited from the English Chalk and Gault.

Table-case 26. The Cretaceous Ctenothrissidæ are herring-like fishes which mimic the Berycoids in the anterior situation of the

pelvic fins and the serration of their scales. The Clupeidæ, or herrings-proper, date back to the same period and are represented both in Mount Lebanon and Brazil by *Diplomystus* (Fig. 105), which is also common in the European and North American Lower Tertiaries, and still survives in the rivers of

Table-case 26.

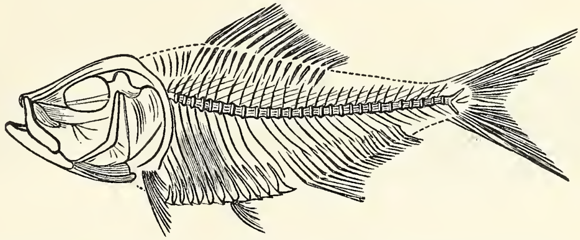

Fig. 105.—Restoration of *Diplomystus brevissimus*, from the Upper Cretaceous of Hakel, Mount Lebanon; somewhat reduced. (After Pictet and Humbert. Table-case 26.)

Chili and New South Wales. *Clupea* itself ranges upwards from the Eocene.

It is interesting to notice that in the Cretaceous seas the herrings and similar fishes already lived in dense shoals, which were sometimes suddenly destroyed. Slabs of hard limestone from Hakel, Mount Lebanon, exhibited in Wall-case 15, are covered with their remains.

Wall-case 15.

The Salmonidæ are scarcely known among fossils. Re-

Table-case 26.

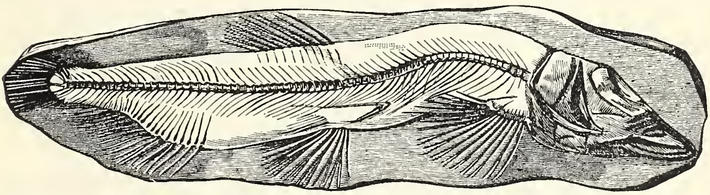

Fig. 106.—Capelin (*Mallotus villosus*) in nodule of Glacial Clay from Greenland; somewhat reduced. (Table-case 26.)

mains of some existing species are found in comparatively modern deposits, and an interesting series of nodules is exhibited from the glacial clays of Greenland, Norway, and Canada, each enveloping a "Capelin" (*Mallotus villosus*). The shape of the nodule (Fig. 106) is observed in every case to correspond precisely with the contour of the enclosed fish; and the concretion is probably due to the escape of gases

Table-case 27. from the decomposing body leading to a concentration of mineral matter from the surrounding clay.

The Dercetidæ are eel-shaped Cretaceous fishes, probably related to the deep-sea Halosauridæ, but with longitudinal rows of scutes or prickles in the skin. One specimen of

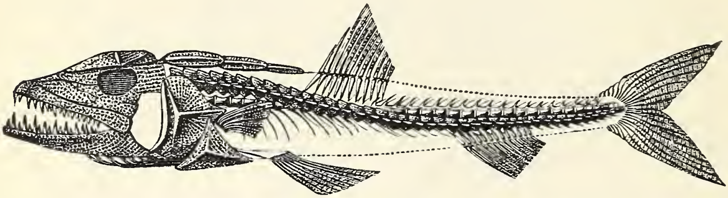

Fig. 107.—Restoration of *Eurypholis boissieri*, from the Upper Cretaceous of Hakel, Mount Lebanon; one-half nat. size. (After Pictet and Humbert. Table-case 27.)

Leptotrachelus, from the Upper Cretaceous of Mount Lebanon, in Table-case 27, shows a large fish in its interior, evidently swallowed, and proving the possession of a distensible stomach.

Wall-case 16. Table-case 27. The Enchodontidæ of the Cretaceous period are also closely allied to modern deep-sea fishes, but to the Scopeloid

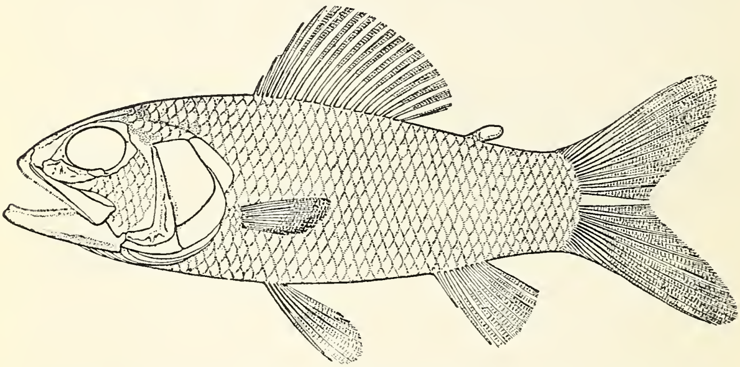

Fig. 108.—Restoration of *Sardinioides crassicaudus*, from the Upper Cretaceous of Westphalia; about one-third nat. size. (After A. S. Woodward. Table-case 28.)

group. They are remarkable for their very powerful teeth. The best-preserved skeletons are those of *Eurypholis* (Fig. 107) and *Enchodus*, from the Upper Cretaceous of Mount

Lebanon; but there are, in addition, numerous skulls, jaws, and other remains of *Enchodus, Halec,* and *Cimolichthys,* from the English Chalk. True Scopelidæ, such as *Sardinioides* (Fig. 108), are well preserved in the Upper Cretaceous both of Mount Lebanon and Westphalia. Probably related to these families also are the flying fishes named *Chirothrix,* from the Lebanon Chalk. **Table-cases 27, 28.**

The pikes, or Esocidæ, and the closely-related "toothed carps," or Cyprinodontidæ, are fresh-water fishes, of which very few ancestors are known. Good skeletons of *Esox* itself are exhibited from the Upper Miocene of Oeningen, Baden. Fossilised shoals of the small *Cyprinodon* are shown in fresh-water marl from the Lower Oligocene of Aix in Provence. **Wall-case 16. Table-case 28.**

Sub-order 5.—**Ostariophysi.**

The past history of all fresh-water fishes is very imperfectly understood. Fresh-water deposits are of such limited extent that they rarely escape destruction for long geological periods; and, except perhaps for a few sediments deposited at the mouths of rivers, geology has as yet revealed little concerning the fresh-water life of Jurassic and Cretaceous times. Of the Characinidæ and Cyprinidæ (carps, &c.), therefore, very little is known among fossils, although they date back to the early Tertiary. The best examples are tench, roach, &c., from the Upper Miocene of Oeningen in Table-case 29. It is equally difficult to discover satisfactory fossil remains of the Siluroids, or "cat-fishes," although some of these are marine. The skull of *Bucklandium diluvii,* from the Lower Eocene London Clay of Sheppey, is typically Siluroid; and fragments from the Bracklesham Beds cannot be distinguished from the corresponding parts of the living genus *Arius.* **Wall-case 16. Table-case 29.** **Table-case 29.**

Sub-order 6.—**Apodes.**

Typical eels have existed since the Cretaceous period, and *Urenchelys,* represented in Table-case 29 by fine specimens from the Upper Cretaceous of Mount Lebanon, only differs from the modern genera in possessing a distinct tail-fin. Well-preserved eels are also found in the Upper Eocene of Monte Bolca, near Verona (*Eomyrus*), and in the Upper Miocene of Oeningen, Baden (*Anguilla*). **Table-case 29.**

Sub-order 7.—**Anacanthini.**

Wall-case 17. Table-case 30.

Cod-fishes are discovered first in the Oligocene black slates of Glarus, Switzerland, which were probably deposited in comparatively deep sea. The fossils belong to an extinct genus, *Nemopteryx*, and are exhibited in Wall-case 17.

Typical flat-fishes, resembling small turbots (*Rhombus*), are exhibited from the Upper Eocene of Monte Bolca; and there are soles (*Solea kirchbergana*) from the fresh-water Lower Miocene of Würtemberg.

Sub-order 8.—**Percesoces.**

Table-case 30.

Although these are intermediate between the old bony fishes and the highest spiny-finned fishes, nothing is known with certainty concerning extinct members of the sub-order below the Upper Eocene. Good specimens of *Atherina*, *Mugil*, and *Sphyræna*, are exhibited from the Upper Eocene of Monte Bolca, and from the Lower Oligocene of Aix in Provence.

Sub-order 9.—**Hemibranchii.**

Table-case 30.

The "pipe-fishes," "sea-horses," and their allies date back to the Upper Eocene, and several fine examples are shown in Table-case 30. *Calamostoma* is a "sea-horse" with a well-developed tail-fin, from the Upper Eocene of Monte Bolca.

Sub-order 10.—**Acanthopterygii.**

Wall-cases 16–18. Table-cases 30–32.

The highest bony fishes with spiny fins first appear in the Upper Cretaceous, and nearly all the principal groups are represented among Eocene fossils. It is remarkable that they have undergone scarcely any change during the Tertiary period. Even so curious a fish as *Mene* (Fig. 111) is represented by typical skeletons in the Upper Eocene of Monte Bolca (Wall-case 17, Table-case 31).

Wall-case 16. Table-case 30.

As might be expected, most of the Cretaceous Acanthopterygii belong to the comparatively primitive family Berycidæ. The wonderfully well preserved specimens of *Hoplopteryx* (Fig. 109) from the English Chalk are especially noteworthy. *Homonotus* is another genus from the English Chalk, while *Acrogaster*, *Pycnosterinx*, and *Dinopteryx* are

from the Upper Cretaceous of Mount Lebanon. The living surface-dwelling genera *Myripristis* and *Holocentrum* are **Wall-case 16. Table-case 30.**

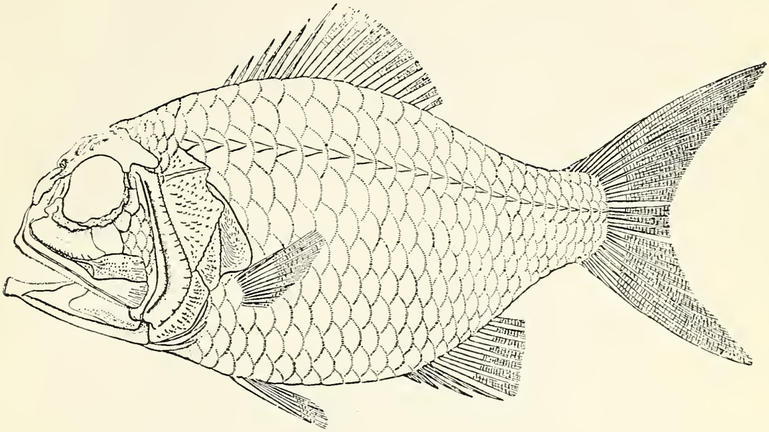

Fig. 109.—Restoration of *Hoplopteryx lewesiensis*, from the English Chalk; about one-third nat. size. (After A. S. Woodward. Wall-case 16, Table-case 30.)

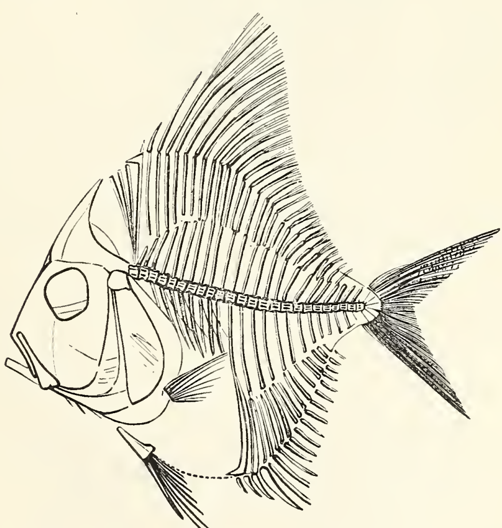

Fig. 110.—Restoration of *Aipichthys minor*, from the Upper Cretaceous of Hakel, Mount Lebanon; nat. size. (After Pictet and Humbert. Table-case 31.)

Wall-case 16. Table-case 30. represented by skeletons from the Upper Eocene of Monte Bolca.

Fishes related to the Stromateidæ (*Platycormus, Berycopsis*) and Carangidæ (*Aipichthys*, Fig. 110) also occur in the Cretaceous of England, Westphalia, Austria, and Mount Lebanon; and an apparently true Percoid is known from the uppermost Chalk of France (*Prolates*).

Wall-cases 17, 18. Table-cases 31, 32. The Tertiary Acanthopterygii, which occupy Table-cases 31, 32, and Wall-cases 17, 18, are mostly referable to existing genera. Among fossil Carangoids *Mene* (Fig. 111),

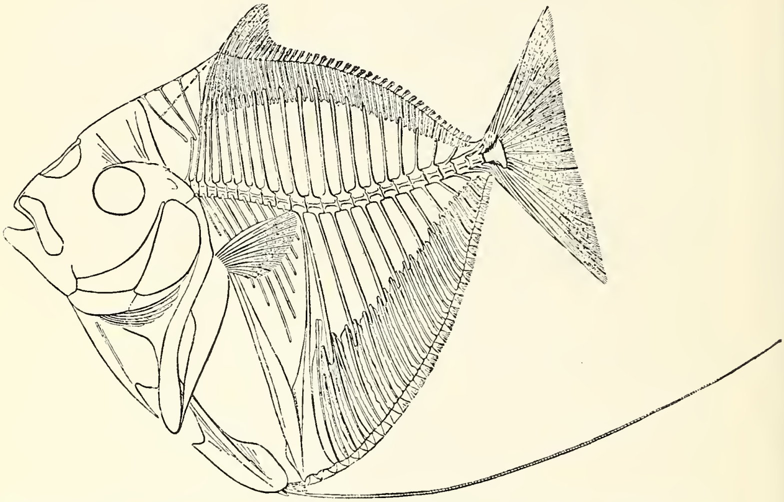

FIG. 111.—*Mene rhombeus*, from the Upper Eocene of Monte Bolca, near Verona; about one-third nat. size. (Table-case 31.)

Vomeropsis and *Semiophorus* (Fig. 112) from Monte Bolca are remarkable. Some of the jaws of the Scombroid *Cybium* from the English Eocene represent unusually large species. The long-bodied slender-snouted Palæorhynchidæ, chiefly from the Oligocene black slates of Glarus, are a strange early Tertiary family; as also are the Blochiidæ from the Upper Eocene of Monte Bolca. *Smerdis* (Fig. 113) is one of the commonest extinct Percoids, from the European Eocene, Oligocene, and Miocene. Sparidæ must have been very common throughout the Tertiary period, but they are usually represented merely by detached teeth (provisionally referred to *Chrysophrys*, etc.). There are, however, many good

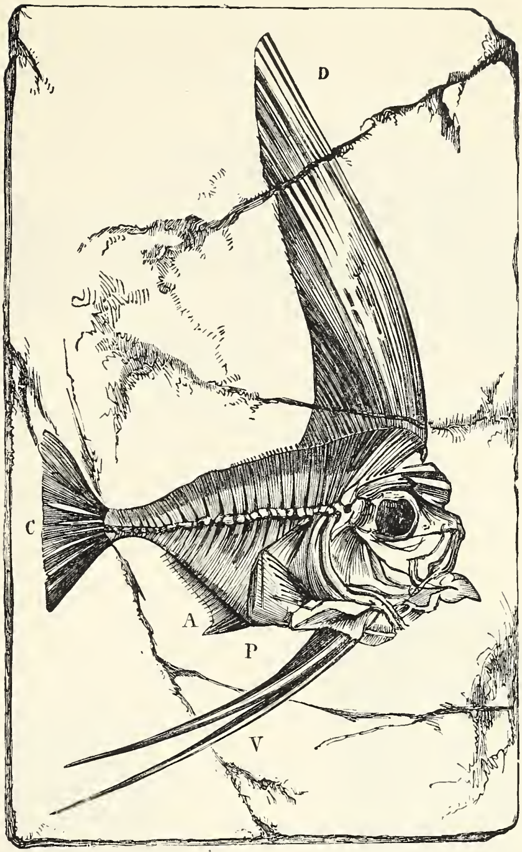

FIG. 112.—*Semiophorus velicans*, from the Upper Eocene of Monte Bolca, near Verona; about one-third nat. size. *A.* anal fin; *C.* caudal fin; *D.* dorsal fin; *P.* below pectoral fins; *V.* pelvic fins. (Table-case 31.)

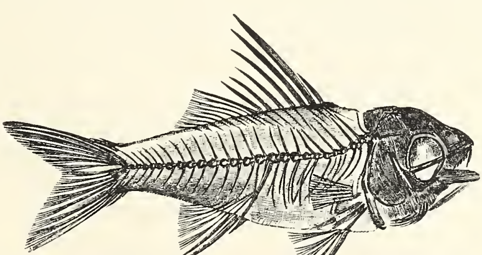

FIG. 113.—*Smerdis minutus*, from the Oligocene of Aix in Provence; nat. size. (Table-case 31.)

Wall-case 18. Table-case 32.

skeletons of the extinct *Sparnodus* (Fig. 114), from Monte Bolca. There are also numerous throat-teeth of Labridæ, or "wrasses," and among these fossils the Eocene *Phyllodus*

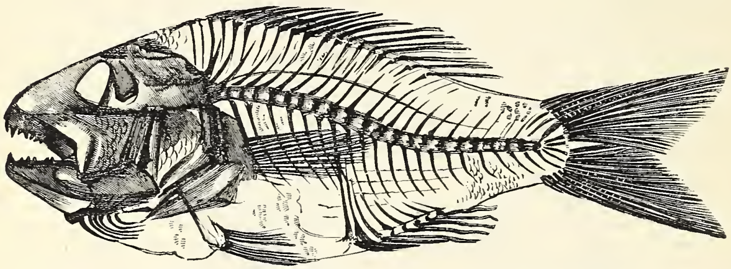

FIG. 114.—*Sparnodus ovalis*, from the Upper Eocene of Monte Bolca, near Verona; about one-third nat. size. (Table-case 32.)

Table-case 32.

(Fig. 115), very common in the London Clay of Sheppey, is especially remarkable. Even the Scleroderms and Gymnodonts date back to the Lower Tertiary. Numerous teeth

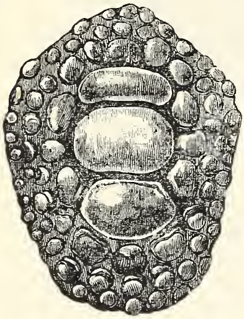

FIG. 115.—Upper pharyngeal teeth of *Phyllodus polyodus*, from the London Clay of Sheppey; nat. size. (Table-case 32.)

FIG. 116.—Teeth of *Diodon scillæ*, inner view, from the Miocene of Malta nat. size. (Table-case 32.)

of *Diodon* (Fig. 116) are exhibited; and there are nearly complete skeletons of the same fish from Monte Bolca and from Oran, Algeria. *Acanthoderma* and *Acanthopleurus* are Scleroderms from the Oligocene of Glarus.

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